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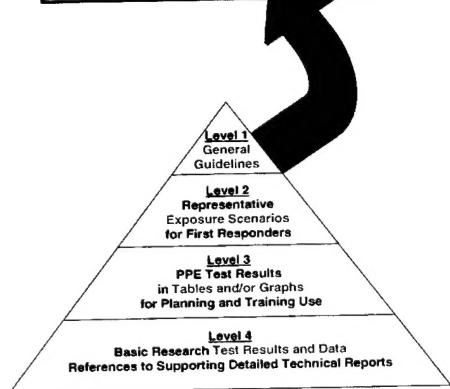
ECBC-TR-132

**GUIDELINES FOR INCIDENT COMMANDER'S USE
OF FIREFIGHTER PROTECTIVE ENSEMBLE (FFPE)
WITH SELF-CONTAINED BREATHING APPARATUS (SCBA)**
FOR RESCUE OPERATIONS DURING A TERRORIST CHEMICAL AGENT INCIDENT.

General Guidelines

"Standard turnout gear with SCBA provides a first responder with sufficient protection from nerve agent vapor hazards inside interior or downwind areas of the hot zone to allow 30 minutes rescue time for known live victims."

"Self-taped turnout gear with SCBA provides sufficient protection in an unknown nerve agent environment for a 3-minute reconnaissance to search for living victims (or a 2-minute reconnaissance if HD is suspected)."



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ENGINEERING DIRECTORATE

January 2001



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Aberdeen Proving Ground, MD 21010-5424

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13. ABSTRACT (Maximum 200 words) This report covers Man In Simulant Testing (MIST) of both new and used firefighter turnout gear. This testing examined how well turnout gear with SCBA protects the firefighter against vapor adsorption at the skin. Firefighters were exposed, while wearing turnout gear with SCBA, to a chemical agent simulant (methyl salicylate) to measure the Physiological Protective Dosage Factor (PPDF). An assessment was conducted using the measured PPDFs to determine quick rescue times for known living victims. The basic result is standard turnout gear with SCBA provides a first with sufficient protection from nerve agent vapor hazards either inside interior or downwind areas of the hot zone to allow 30 min rescue time for known live victims.			
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EXECUTIVE SUMMARY

The concepts outlined in this report are neither mandated nor required procedures for first responders to the scene of a chemical terrorism incident. Rather, they are presented to provide technical and operational guidance for those communities that would choose to perform quick rescue and related operations should this event occur in their communities. We encourage you to review the data, understand the implications, and consciously decide if your fire company would perform such operations. Once you have made the decision that is best for your community, you should train accordingly.

This information is also presented with the understanding that responders and victims exiting the rescue scene will immediately undergo a water (high volume-low pressure) decontamination. A companion report is currently in process to assist in the decontamination process.

The results presented are for firefighters dressed in commonly-used turnout gear, including both new and used Polybenzimidazole (PBI) turnout gear and new and used Nomex® turnout gear. The U.S. Army Soldier and Biological Chemical Command (SBCCOM) tested turnout gear with Self-Contained Breathing Apparatus (SCBA) to determine the performance of each of these Firefighter Protective Ensemble (FFPE) configurations.

This report provides potential Incident Commanders (ICs) with practical displays of FFPE test results for application to first responder operations and training. The displays address both situations where the IC has knowledge of the class, type, and/or concentration of chemical agent involved, and situations where these factors are not known.

These displays are intended as guidelines to assist potential ICs on decisions to enter chemical agent vapor environments to perform rescue, reconnaissance, mitigation, or detection operations. They provide approximations of the amount of time a first responder, outfitted in various configurations of turnout gear, might be exposed to these hazardous environments before experiencing symptoms of such exposure. **Each jurisdiction and/or potential IC is encouraged to use these estimations to establish policy, provide guidelines for operational situations, and/or train first responders on minimum criteria for entry.** Such criteria may include range of allowable activities, required or recommended level of protection for

each activity, and exposure time restrictions/guidelines for removing vapor-exposed responders from the hot zone.

These displays provide both operations and planning/training guideline recommendations. These guidelines are based on results of testing with chemicals that simulate known characteristics of specific chemical agents. These guidelines rely on computer modeling of residual vapor hazards after an assumed terrorist attack with chemical agents. In an actual situation, first responders will operate in a hazardous environment as long as the incident requires, their SCBA air supply lasts, and they remain capable, within the constraints of local command policy. These guidelines do not replace such command policy or lawful orders, however, they can be used to develop command policy or assist the Incident Commander.

For easy dissemination, this report is available at the following web-site:

<http://www.nbc-prepare.org>

The remainder of this summary provides background on how this report came to be.

Congressional legislation signed in 1996 provided a method for the Department of Defense (DoD) and other federal partners to assist the first responder community at the state and local level in preparing for a potential chemical or biological terrorist attack. Under the Nunn-Lugar-Domenici Domestic Preparedness Program, SBCCOM formed teams of operational and technical experts (see Appendix C) to focus on high priority responder needs through an effort called the Improved Response Program (IRP). Based on experience gained during an exercise series called BALTEX, the IRP identified a gap in first responder knowledge on how to perform rescue operations, both safely and quickly, after an incident involving highly toxic chemical warfare agents. Specifically, potential ICs needed to know how well Firefighter Protective Ensemble (FFPE) with SCBA, commonly called turnout gear, would protect when first responders do not have fully-encapsulating Level A protective equipment rapidly available to perform entry operations.

Under the 1998-1999 IRP, and both with operational input and active participation from a broad community of first responders, SBCCOM conducted a series of technical tests. Firefighters from Montgomery County (MD) and Baltimore County (MD) participated as test subjects. These tests identified and validated how well both standard and field-modified configurations of existing

turnout gear protect a first responder from injury, incapacitation, or death while operating in an environment containing chemical agent vapor.

To put these test results into terms usable by firefighters throughout the nation, an Incident Command Research Team was formed under the IRP (see Appendix C). The IC Research Team included firefighters representing:

- Montgomery County (MD)
- Baltimore County (MD)
- Baltimore City (MD)
- Howard County (MD)
- Washington, DC
- Columbus City (OH)
- Los Angeles (CA)
- Aberdeen Proving Ground (MD)

Representatives from this research team consulted with a cross-section of additional firefighters at all ranks through face-to-face interviews, a questionnaire survey, and in meetings. These efforts help to ensure the format and content of this report put the test results into operational terms that can be used by first responders and potential ICs in planning and training for a chemical agent incident response.

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PREFACE

The work described in this report was funded by the Domestic Preparedness Program. This work started in February 1998 and was completed in August 1999.

The use of either trade or manufacturers' names in this report does not constitute an official endorsement of any commercial products. This report may not be cited for purposes of advertisement.

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Acknowledgments

The authors gratefully acknowledge the help and assistance of the firefighters from Montgomery County Fire and Rescue Service and Baltimore County Fire Department who contributed their time, experience, and equipment to assist us in completing the technical testing. Their participation during both the initial and follow-on testing was invaluable.

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FIRST RESPONDER EXPOSURE DANGERS

Agent Types, States, and Exposure Routes

Several chemical agents may be manufactured easily in the quantities expected for a viable terrorist threat. Often, physical evidence could help assess which chemical agent may be present after a terrorist attack. For example, several chemical agents can be smelled at or below concentrations where they become toxic hazards, so odor reports from victims may be an important indicator. However, as shown in Table 1, agents GB and VX in pure forms are odorless, so lack of smell is not evidence of safe exposure levels.

Table 1. Chemical Agent Vapor Odors and Exposure Symptoms

Chemical Agent			Odor	Potential Vapor Exposure Symptoms (Immediacy ¹ , Exposure Route) [Exposure Severity]
Type	Name	Class		
GB	Sarin	Nerve	No Significant	(immediate, eye contact effects) Pinpointing of pupils, blurred or dimmed vision, eye pain, headache;
GD	Soman		Fruity, Camphor	(delayed, skin contact effects) Increased local sweating, tremors [mild exposure] Vomiting, nausea, headache [moderate exposure] Convulsions, diarrhea, loss of consciousness, death [severe exposure];
VX	-		No Significant	(delayed, inhalation effects) Vomiting, nausea, headache, convulsions, diarrhea, loss of consciousness, death
L	Lewisite	Blister	Geraniums	Pain, irritation, burn (immediate, skin contact effects) Blisters (slightly delayed, skin contact effect)
HD	Mustard		Garlic-Like	No immediate ²

¹ Dependent on exposure rate and total dosage

² Skin reddening and blisters generally are delayed by 4 to 18 hours after exposure

At normal indoor temperatures, chemical agents may be disseminated as a liquid, aerosol, and/or vapor. These dissemination forms effectively are a continuum of mass sizes. Smaller masses suspend in air longer and may be removed by ventilation, as would any other vapor. Liquid and aerosol droplets deposit on surfaces and become both potential skin contact hazards and sources for evaporation and reaerosolization. Vapors can adsorb onto surfaces and subsequently offgas as vapor.

This report provides estimations of the residual vapor hazard potentially faced by first responders. **It does not address aerosol or liquid hazards.** However, aerosol testing by SBCCOM has shown that new PBI turnout gear offers significantly better protection against chemical agent aerosols than chemical agent vapors. Therefore, vapor is a greater hazard to first responders. However, when entering an area contaminated with liquid chemical agent, contact with liquid must be avoided.

WARNING

Even small amounts (several droplets) of liquid nerve agent contacting the unprotected skin can be severely incapacitating or lethal if the victim or responder is not decontaminated rapidly (minutes) and treated medically.

After a terrorist event, chemical agent vapor could affect first responders through three potential exposure routes – skin contact (percutaneous), inhalation, or ocular effects. This report addresses vapor hazards through all three exposure routes. Compound effects through multiple, simultaneous exposures are not reflected in maximum exposure times found in the tables and graphs, except for scenarios involving high vapor concentrations of chemical agents GB and GD. For these scenarios, compound effects are reflected in the Level 1 General Guidelines and all related tables and graphs.

Most tables and graphs describe only the vapor percutaneous hazard. Limiting the exposure route was based on analysis of the systemic nerve agent effects from compound simultaneous inhalation and percutaneous exposures. This analysis found that, except for scenarios involving agent GB and one scenario with agent GD, chemical agent vapor that penetrates FFPE accounts for 90 percent (or more) of the overall systemic hazard. Therefore, compound simultaneous vapor exposure through the SCBA (inhalation) and turnout gear (percutaneous) does not change significantly the tables and graphs.

The SCBA protects both the firefighter's eyes and respiratory system from agent effects. This protection is much greater than the protection provided to skin by FFPE. However, direct exposure of the eyes, even to extremely low vapor concentrations of nerve agents GB and GD, may cause an ocular effect. The pupil of the eye becomes smaller (contracts), making it more difficult to see in low light areas. This ocular effect, also called miosis, could occur between four and 10 times sooner than chemical agents effects might occur due to exposure of FFPE-protected skin to the same vapor concentration.

Miosis may occur after several seconds of exposure in a saturated GB or GD environment and could take five to 10 minutes to fully develop. Miosis is reversible after exposure ceases, but should be medically evaluated. Firefighters following the Level 1 General Guidelines will be able to see well enough to exit in all but the lowest of light conditions.

Vapor Dosage Calculation



In general, exposure to a chemical agent vapor concentration (C) over time (T) produces an exposure dosage (CT). As vapor concentration and/or exposure time increases, exposure dosage will become higher. Furthermore, exposure dosage is cumulative; natural detoxification after nerve agent exposure may take weeks to months. However, medical intervention after nerve agent exposure is very effective for all but the most severe of exposures.

While nerve agent exposure can be detected by observing victims, symptoms of exposure to mustard (HD) are latent, and may not appear for four to 18 hours after exposure. Most mustard-exposed victims may have left the incident scene and seem relatively unaffected, even several hours after the event and almost regardless of the HD agent concentration. Although mustard effects may take several hours to develop, tissue damage from mustard exposure is not reversible despite this delay and regardless of medical intervention.

Risk Factors Inside Enclosed Areas

Determining the actual concentration of chemical agent vapor that a first responder might encounter during rescue or reconnaissance requires knowledge of the major controlling factors. These factors can be recalled using the acronym "REACT". When these factors are not known, the IC must assume, tacitly or wittingly, one or more of these significant parameters in making a decision on operating within the hot zone.

Rescuer FFPE - The IC must consider the availability of higher protective FFPE configurations and the speed of donning FFPE weighed against the risk of danger to each firefighter and the number and criticality of rescue needs. Tables and graphs presented in this report will help the IC evaluate these hazards versus the benefit of ensuring each additional level of FFPE.

Environment - The behavior of vapor-laden air within each enclosed environment is important to the speed that the vapor hazard changes. If no active measures are taken to remove or mitigate the vapor and/or vapor source within a room, the existing air handling conditions will

dictate how the level of hazard reduces or builds. This hazard will reduce most rapidly with high ventilation and good mixing within a room with smaller volume.

Another important factor is the amount of air mixing within the room. This report assumes the air within each room is well mixed.

Major Factors - Indoor Vapor Hazard to Responders

- Rescuer Fire Fighter Protective Equipment
- Environment
 - Room Size and Air Turnover Rate
 - Air Mass Mixing
 - Proximity to Offgas Path
- Agent-Unique Factors
 - Type & Toxicity
 - Volatility
- Concentration
 - Liquid Agent Amount/Purity/Surface Area
 - Vapor Agent Concentration
- Time...
 - Since the Event
 - Of Exposure Duration



Summary Insert

However, the amount of mixing will depend on the rate, type, and location of chemical agent dissemination, total and local air exchange rates, and the time elapsed since the event. For example, after explosion of a nerve agent device inside an auditorium, the concentration of

chemical agent in the direct vapor transport path from the site of the explosion to the room air conditioning exhaust may be higher than areas with relatively more "dead" air further away from this site. Firefighters may be able to avoid such areas, either by inspection or by introducing a small amount of smoke to quickly characterize local air movement patterns.

This report assumes ventilation factors using half the ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) Standard 62-1989 applied for each room. This amount of ventilation is similar to that used in 1978 to 1988 building codes, and is conservative of the 1989 standards, allowing for some amount of poor mixing.

Agent-Unique Factors - Each chemical agent has known toxicity and volatility. Toxicity is a measure of the amount of exposure (dosage) that will induce various levels of incapacitation or death. Volatility is a measure of how much chemical agent a given air mass can hold at a given temperature, and is one component of the rate of evaporation of liquid or aerosol into that air mass as vapor.

By comparison of different agents in similar scenarios, the IC can understand the relative toxicity and volatility of each unique agent treated in this report.

Concentration - If an air mass is not saturated with chemical agent vapor (holding as much as it can hold), then the vapor hazard may be limited by the amount or dissemination method for the chemical agent employed. This is intuitive; smaller and less efficient devices may present lower hazards.

Without a detector capable of quantifying agent concentration, or other physical evidence such as victim symptoms, the amount and dissemination method for each chemical agent must be assumed. For this report, specific challenge concentrations, based on assumed dissemination

methods of defined chemical agent volumes, were modeled for each Level 2 scenario and are presented as Level 3 tables and graphs in Appendix B.

Time - Both the time since the event and the exposure duration time for each first responder are major factors for operating in the hot zone. These factors also are the most controllable by the IC. In general, the hazard to first responders in FFPE will be lower the longer the delay before entry and the shorter the exposure time in the hot/warm zone.

WARNING

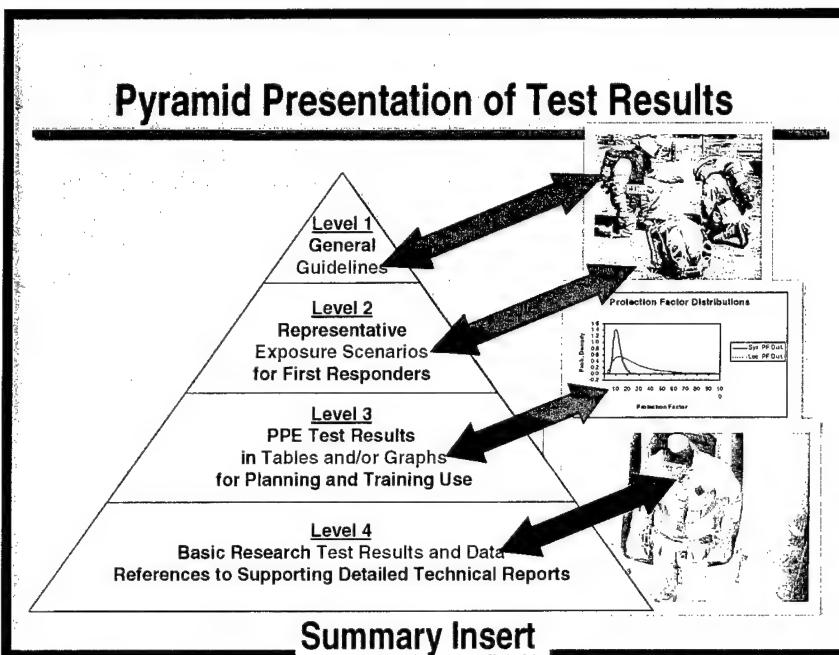
Minimizing rescuer exposure duration will minimize their potential hazard. However, a rescuer in standard turnout gear with SCBA is protected adequately for 30 minutes, even without taking time to apply quick fixes, such as duct tape. Time delays before rescuing known live victims may increase the cumulative dosage a victim receives. Quick entry, rescue, and exit, while diligently avoiding any contact with liquid contamination, will minimize the hazards to victims and rescuers.

DETERMINING SPECIFIC HAZARDS TO FIREFIGHTERS

A basic issue is determining what vapor concentration a firefighter might encounter while performing rescue or reconnaissance. While an underlying assumption might be that first responders would enter a hot zone only to rescue living victims, some jurisdictions or ICs may want to risk entry to perform other missions such as reconnaissance, sampling or detection, or mitigation. Therefore, the potential vapor environments we consider in this report range from concentrations below detection levels to fully saturated vapors.

If a chemical agent detector capable of accurate near-real-time vapor quantification is not available and/or entry into an unknown environment for detection is not performed, the IC must operate based on other indicators. These include signs and symptoms and reports from escaping victims, and knowledge of the room size and air handling characteristics.

To best understand the basis for these recommended guidelines, we present the logic using a tiered approach to interpreting and presenting test results. At each of four levels within a building block “pyramid”, we present test results with successively more technical and detailed explanations of the rationale used to obtain those results.



The top of the pyramid is the Level 1 General Guidelines for entry into an unknown nerve agent vapor environment. This guideline shows that, even in the highest possible concentration of nerve agent vapor, first responders in turnout gear and SCBA have some capability to rescue victims. Since these guidelines are

based on several assumptions about the size and severity of the event that created the vapor hazard, these assumptions are explained clearly in the supporting levels of the pyramid.

The General Guidelines provide quick rules of thumb for operation in known and unknown environments. Additional data in Table 2 may be used when the agent type is known, or when more information on the potential risk to first responders is needed.

NOTE

Additional information that can be used for planning and training is provided in Appendix B. Appendix B starts with a description of specific Level 2 Exposure Scenarios used to model the representative residual hazards used in Level 3 tables and graphs. Three representative indoor rooms were chosen for modeling based on their combination of feasibility as a terrorist target and their range of ventilation and room volume. An office or mailroom inside a building represents a reasonable worst-case scenario because the room volume and typical ventilation rates are low. Conversely, an auditorium has high room volume, but may still have low ventilation rates, whereas a restaurant has higher ventilation within a still relatively small room volume. These scenarios represent likely bounds of room performance.

At Level 2, we help to bridge the gap between our generalized top-level conclusions (Level 1), and the test results displayed at Level 3 (Tables and Graphs). Using the tables and graphs in Level 3 will allow the IC to have more specific answers to the problems faced in individual situations. For example, while the General Guidelines recommend restricting entry into unknown chemical agent vapor environments to a very short period, having direct knowledge of:

- how the responder is protected
- agent type/class/concentration
- time since the event
- information about the room

will allow the IC to get a more realistic idea of recommended exposure time limitations.

LEVEL 1 - GENERAL GUIDELINES

An incident commander may need to decide the safety and feasibility of first responders entering a vapor-contaminated room to assist known casualties, regardless of his knowledge of the chemical agent or agent concentration in the area being entered. Similarly, the IC may need to decide on risking a reconnaissance to determine if rescuable victims remain.

The Level 1 principle provides general guidance for maximum responder exposure time. Level 1 exposure times are derived from modeling of actual test results for a limiting case. For rescue of known living victims, the limiting case is the fact that exposure periods greater than 30 minutes were not evaluated during simulant trials. However, for reconnaissance into an unknown chemical agent vapor environment without known living victims, the limiting case is based on exposure to GB vapor at its highest possible room temperature concentration. This is exposure to an extremely toxic and volatile nerve agent at concentrations that can be fatal within seconds to a person without respiratory protection. In other words, at full GB vapor saturation, all unprotected victims would have escaped immediately or died soon after exposure.

In using the Level 1 guidelines, the following assumptions should be clearly understood and are key to protecting the rescuer:

Level 1 - General Guidelines

"Standard turnout gear with SCBA provides a first responder with sufficient protection from nerve agent vapor hazards inside interior or downwind areas of the hot zone to allow 30 minutes rescue time for known live victims.

Self-taped turnout gear with SCBA provides sufficient protection in an unknown nerve agent environment for a 3-minute reconnaissance to search for living victims (or a 2-minute reconnaissance if HD is suspected")

Summary Insert

1. Rescue entry occurs after vapor concentration has peaked (assumed approximately 10 minutes after release of the agent).
2. The firefighter performing reconnaissance will exhibit no more than threshold symptoms of nerve agent exposure (dim vision, headache, eye pain).

Under these conditions, a firefighter wearing turnout

gear and properly fitted pressure demand or positive pressure SCBA, who are performing rescue of known live victims, will be protected from threshold symptoms of nerve agent exposure due to vapor exposure for 30 minutes, provided they do not contact liquid chemical agent. Responders in self-taped turnout gear and properly fitted SCBA can perform entry into areas of unknown chemical agent vapor environments for 3 minutes without risk of more than threshold symptoms. If mustard (HD) vapor is suspected, limit exposure time to 2 minutes to avoid delayed onset of threshold symptoms (skin reddening).

Known Living Victims

The maximum exposure time for rescue of known living victims was determined by using the victim as a detector. If at least one victim remains alive 15 minutes after the incident, a rescuer can assist that victim with little or no risk (threshold symptoms at worst) while wearing turnout gear with SCBA, or more protective FFPE configurations. Indeed, use of the human as a detector indicates the nerve agent vapor concentration is relatively low compared to the range of concentrations achievable.

Modeled maximum exposure times for rescue of known living victims all exceed 30 minutes. However, because test results were based on 30-minute exposures, and most SCBA operations would be limited to not much more than 30 minutes, no estimates greater than 30 minutes are provided in this report.

Unknown Environments

Responders entering an unknown nerve agent vapor environment for reconnaissance should assume worst-case conditions and assume agent GB for nerve agent. However, if the **chemical agent is known, or the firefighter performing reconnaissance is not self-taped**, the Level 1 General Guideline 3-minute rule should be modified by entering Table 2 below with the FFPE configuration worn.

Table 2 shows maximum exposure time estimates for various FFPE configurations inside a room saturated with chemical agent vapor. If, during reconnaissance, living nerve agent exposure victims are discovered at least 15 minutes after the chemical agent release, the maximum exposure time should be revised to 30 minutes.

Enter Table 2 with FFPE configuration and agent type. If agent class is unknown, use the shortest exposure time for a given FFPE configuration. If agent class is known, but specific agent type is unknown, use the shortest exposure time for the agent class in a given FFPE configuration.

Table 2. Maximum Reconnaissance Exposure Time¹ (Unknown Environment²)

Agent	First Responder Symptom Level	Maximum Reconnaissance Exposure Time ³ (minutes) for Various "Quick Fix" Turnout Gear Configurations ⁴			
		Turnout	Self-Taped Turnout	Buddy-Taped Turnout	Tyvek Suit Under Turnout
GB	Threshold ⁵	1.5	3.0	4.0	5.0
	5% Lethal ⁶	4.0	6.0	7.0	9.0
GD	Threshold ⁵	1.5	4.0	6.0	9.0
	5% Lethal ⁶	5.5	10	12	18
VX	Threshold ⁵	17	24	28	30
	5% Lethal ⁶	30	30	30	30
HD	Threshold ⁷	0.7	2.0	9.0	6.0
	5% Lethal ⁸	30	30	30	30

1 Based on physiological thresholds established by the National Academy of Science*

2 Assumes a constant, saturated vapor environment

3 Chemical agent present at its room temperature vapor pressure

4 See the next section for descriptions and photographs

5 At this exposure time, 1 in 2 responders would have onset symptoms of increased sweating and muscle weakness.

6 At this exposure time, 1 in 20 responders may die without medical treatment.

7 At this exposure time, 1 in 2 responders would develop localized skin reddening and possible blisters 4-18 hours after exposure.

8 Maximum exposure time is limited to 30-minutes because MIST trials did not exceed 30 minutes. Therefore, physiological protective dosage factors after 30 minutes were not defined. Assuming no significant change in physiological protective dosage factors during exposures after 30 minutes, the maximum exposure times to half the 5% lethal effects range from 31 minutes (standard turnout gear) to 98 minutes (buddy-taped).

The maximum exposure times recommended in the Level 1 General Guidelines and in Table 2 are based on an extensive series of tests conducted at the Edgewood Chemical Biological Center (ECBC), Aberdeen Proving Ground, MD. These tests provided raw data for modeling the Physiological Protective Dosage Factors used in this report. Physiological Protective Dosage Factor (PPDF) is defined as the ratio of the dosage that effects a protected person divided by the dosage that similarly effects an unprotected person. Firefighters in turnout gear with properly fitted SCBA performed mock rescue operations for 30 minutes inside a chamber filled with a non-toxic chemical vapor which simulates the vapor properties of an actual chemical agent.

* Review of Acute Human-Toxicity Estimates for Selected Chemical-Warfare Agents, Committee on Toxicology, National Research Council, 1997

MUSTARD AGENT (HD)

Agent HD (mustard) is included in this report because HD is a well-known vesicant (blister agent) that is relatively easy to manufacture. However, HD may be an unlikely threat for several reasons. Furthermore, victims and responders might not recognize an HD attack, so there would be no rescue mission. Consider that:

- HD freezes into a solid at less than 58° F, so HD is difficult to disperse in cold air or through an air conditioning system. A relatively large amount of liquid HD is required to generate a high-concentration vapor.
- Mustard vapor has a disagreeable garlic-like smell at concentrations well below its lethal concentration. People will remain ambulatory and tend to move out of the area long before any potential incapacitation.
- Symptoms for HD are delayed for up to 18 hours, making rescue unnecessary unless a victim were injured or incapacitated for another reason. With moderate HD vapor concentrations, the worst effects for unprotected victims are vision-blurring, eye mattering (conjunctivitis), skin reddening, and blisters. There may be corneal damage if the victim's eyes are exposed.

For firefighters protected by standard turnout gear with properly fitted SCBA, concentrations that will cause delayed, localized skin reddening and blisters could occur where gaps or inadequate closures of the FFPE allow skin exposure (collar and wrists areas). However, although they have more protection, moist areas of the body (crotch and underarms) are most susceptible to HD skin effects. Although these areas can be affected in under a minute of exposure, symptoms would not appear during operations.

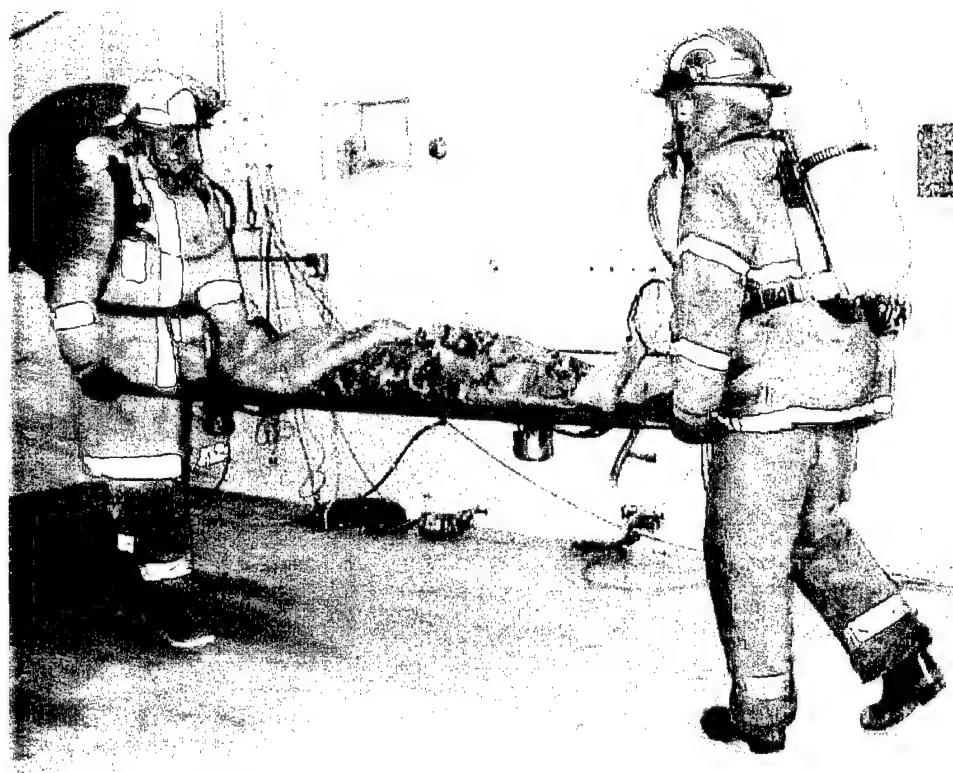
The tests, known as Man in Simulant Test (MIST) trials, measured how well FFPE, in standard and field-modified configurations, protected 17 individual skin areas of the body compared to having no protection. The U.S. Army SBCCOM Domestic Preparedness Chemical Team, also sponsored MIST testing at the Royal Military Academy (Kingston, Ontario, Canada) that confirmed and independently validated the ECBC test results.

SUMMARY OF MIST TRIAL TESTS AND MODELING

The Man In Simulant (MIST) trials were conducted with volunteer career firefighters. For each test, special vapor samplers are placed on the skin of a test subject volunteer at 17 different locations. These samplers absorb chemical simulant vapor at the same rate that human skin absorbs chemical agent vapor. Then the test subjects don either standard turnout gear with SCBA or they don one of the "quick fix" variations of turnout gear/SCBA discussed later in this report. The volunteers enter a vapor chamber containing a measured concentration of simulant vapor and perform a specific series of activities that represent actions expected while rapidly rescuing an individual from a chemically contaminated environment. After 30 minutes, the test subjects leave the chamber and doff their protective clothing. The samplers are removed and analyzed to determine the amount of simulant vapor collected by each sampler. This indicates the amount of vapor exposure in the body region where each sampler was placed, and provides evidence of the protection offered to each skin area by each tested configuration.

The MIST trial results then were used in modeling to determine, based on known physiological thresholds and effective dosages, the local and/or systemic potential effects of each of the chemical agents GB, GD, HD, and VX. These test and modeling results are used in this report to support the General Guidelines and other related tables and graphs.

The photographs on the following page show a vapor sampler affixed to a skin sampling location, and firefighters performing a one-man drag and a two-man carry during MIST trials.



Quick Fix Turnout Gear Configurations

As reflected in the General Guidelines and Table 2 above, several potential field expedient configurations, known as “quick fixes”, were tested alongside standard turnout gear during the MIST trials. Quick fixes involve taping turnout gear closures and openings with duct tape and/or wearing a protective undergarment (Tyvek® ProTech F), hereafter called Tyvek undergarment.

These configurations significantly increase the level of protection offered by standard turnout gear. Descriptions and photographs of each quick fix are provided below.

Buddy-Taped

Buddy taping involves totally taping FFPE openings and closures. An unencumbered firefighter should perform buddy taping on the responding firefighter. To provide the same protection that was demonstrated during MIST trials, all seams, seals and closures of the FFPE should be taped



thoroughly with three strips of two-inch wide duct tape as follows.

Tape the:

- boots to trouser cuffs
- trouser fly shut
- trouser waist to the uniform shirt
- jacket bottom to the trouser waist
- front closure of the jacket shut
- jacket collar to the hood
- hood to the mask and to the ear flaps of the helmet
- jacket cuffs to the gloves

Although not done during testing, tape should be wrapped around the waist sufficiently to hold the jacket close to the body.

Self-Taped

Self-taping is a rapid method of increasing protection offered by standard (untaped) turnout gear when responders elect not to take the additional time to buddy tape, or when a buddy is not



available. Self-taping may not be as extensive as buddy taping, and the protection offered is not as great. For the MIST testing, the following self-taping was performed by each test subject:

- boots to trouser cuffs
- trouser fly shut
- trouser waist to uniform shirt
- front closure of the jacket shut
- jacket cuffs to the gloves
- Belt around waist to shut jacket

Taping closures about the head will increase protection. However, without a buddy, the firefighters performing the MIST trials felt this was too difficult to be an effective field option.

Tyvek Undergarment

To examine how much added chemical protection might be obtained using an additional, inexpensive coverall suit, tests were performed using a full suit of Tyvek under FFPE turnout gear with SCBA. Additionally, during the MIST trials, the Tyvek undergarment was self-taped at the wrists and the hood was buddy-taped to the mask and around the neck openings. However, no other turnout gear openings or closures were taped. A photograph of head and neck closure taping is provided below.

Although this configuration provided the most protection of all tested configurations, it did greatly increase the physiological heat burden.



MITIGATION

On-Scene Vapor Detection

During an actual event, the uncertainty in making command decisions may be reduced by use of



an accurate and real-time chemical agent vapor detector. Unfortunately, few jurisdictions will have such capability.

Any on-scene knowledge of the class, type, and/or concentration of the residual hazard will help the IC to better evaluate operational hazards. For example, knowing the chemical agent type will ensure a more accurate estimation of maximum exposure time. Also, as illustrated by an example in Appendix B, Graph A can be entered directly with a measured

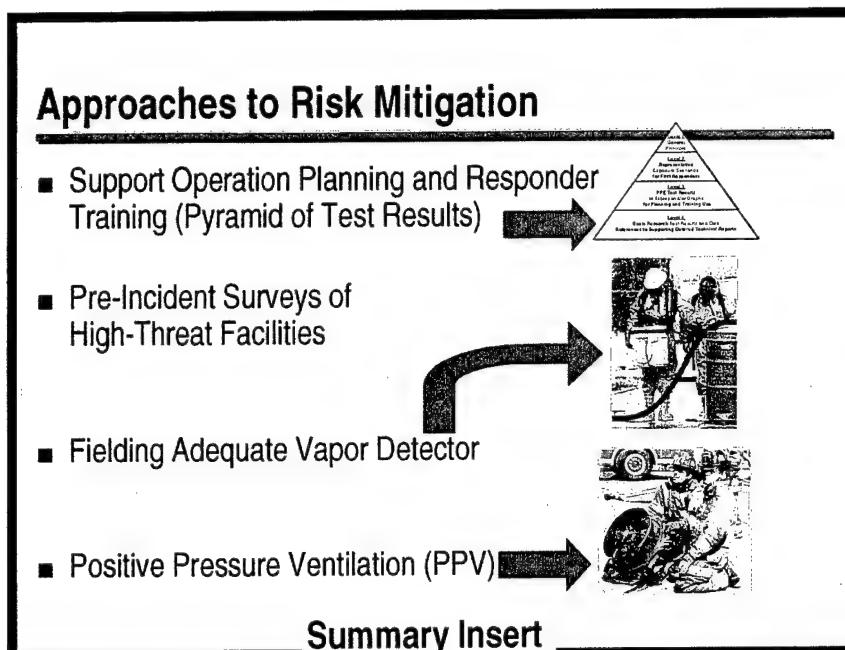
agent concentration, rather than assuming the concentration based on the Level 2 scenario, to improve estimate accuracy.

Operation Planning and Responder Training

Incorporating the information presented in this report into firefighter policy, procedures, and training will reduce the hazard to individual firefighters and may reduce suffering and death of affected victims. This report should instill confidence that quick and effective rescue of chemical terrorist victims may be accomplished without significant hazard to properly trained and equipped firefighters. See Appendix A for a generic approach to "sizing up" and performing rescue and reconnaissance operations after a chemical agent incident.

A strawman procedure for rescue operations is provided at Appendix A. This appendix is intended to provide a generic approach that any jurisdiction easily can tailor or modify to meet local policy, procedure, and training requirements within the constraints of available staff and any equipment limitations.

Pre-Incident Surveys



Since several significant parameters that control the residual vapor hazard depend on the specific physical controls and dynamics of air circulation within an enclosed space, knowing these parameters, either by prior survey or on-scene consultation with a building engineer, may improve the quality of IC decisions.

Identify High Threat Facilities and Events - In consultation with local law enforcement agencies and the FBI, firefighters may be able to determine specific facilities and/or pending events that may be potential terrorist targets. In fact, local jurisdictions may already be performing inspections and other agencies may be performing indoor air quality surveys of buildings/rooms. If department resources permit, either by piggy-backing on these surveys or by performing a dedicated effort, a pre-incident survey might allow specific characterization of room performance.

Ventilation and Air Handling Factors - For expected targets, surveys might include efforts to determine how rooms of concern compare to the Level 2 scenarios in terms of ventilation, air mixing, and total volume. Possible areas of inspection include:

- Technical review of blueprints, drawings, and HVAC specifications. Determine when the facility was built to evaluate how well it might meet local building codes and/or ASHRAE standards. If not already known, determine how to locate the building engineer 24-hours per day.
- Room Characterization. Will the owners and local ordinances allow testing with smoke or tracer gas?

- Location of HVAC controls. Can they be rapidly or remotely accessed to increase fresh air to 100 percent of recirculation air? Can local exhausts be activated rapidly? How are rooms zoned?
- Inspect the room intake air damper for proper operation. Locate all ventilation controls such as fresh air dampers.
- Special considerations. Are there doorway airlocks that may limit the efficacy of ventilation, act as a vapor hold-up area, or even protect rescuers or serve as a victim staging area?

Doors, Windows, Vents, and Exhausts - Locate all doors, windows, vents, and exhausts that might be used to reduce a residual vapor hazard by increasing ventilation.

Prevailing Wind and Downwind Hazards - Evaluate known wind patterns and the flow pattern for exhaust air to determine if nearby building occupants should be notified to evacuate.

Active Hazard Mitigation

Hazards can be mitigated by three general methods: reducing exposure time, reducing agent concentration, or improving equipment.

Reduce Exposure Time - Reduce exposure time by making an organized entry operation. The responder should enter rapidly with a purpose, necessary equipment, and sufficient back-up to accomplish the operation (e.g. reconnaissance to identify live victims) without delay. Recognize that, even after exiting the hot zone, turnout gear still holds contaminated vapor inside, so the responder must remove turnout gear as soon as possible after exiting the hot zone into a contamination-free upwind area (cross-wind from victims), especially if the responder experiences onset of exposure symptoms.

Reduce Agent Concentration – Chemical agent vapor concentration can be reduced by several methods. Ventilation is one of the most dependable methods. For every room volume of air that is displaced, theoretically the agent vapor concentration is reduced by 63 percent if the air is well mixed. However, experience shows that air normally does not mix well due to barriers, room size, and other factors, so chemical agent vapor concentration may be reduced by a much lower factor, perhaps only 10 percent.

Opening the fresh air inlet fully on the air handler can speed vapor concentration reduction rate.

Many air handlers operate at 15 to 25 percent open; increasing the fresh air makeup to 100 percent can increase the rate of agent removal by up to a factor of 6.

Positive Pressure Ventilation (PPV) fans have been used in testing by SBCCOM to determine their utility in reducing residual vapor hazards. Preliminary data indicate that PPV is highly effective, and may reduce chemical agent vapor concentrations by between 40 and 75 percent within 10 minutes of emplacement and operation.

WARNING

PPV fans do not destroy chemical agent vapor. Rather, these fans move chemical agent vapor outside and downwind of the building or possibly to other interior rooms. Although these displaced vapors have lower concentration, they still may cause additional potential victims. Before initiating ventilation, evacuate all areas that may be contaminated by displaced chemical vapors.

When using PPV or increasing makeup fresh air, use caution to minimize spreading contaminated air into uncontaminated areas of the facility. If the responder has to enter through the contamination being ventilated, responder exposure will increase and maximum exposure time will be reduced. Given a choice of entrance paths, SBCCOM testing shows that responders should enter through a doorway where a PPV fan is blowing fresh air into the building.

For liquid chemical agent on a floor, spreading vermiculite and/or covering over the spill or droplets with firefighter foam can substantially reduce vapor hazard, based on results of vapor suppression tests conducted by SBCCOM. Vermiculite may also help to contain the spill. However, spills or droplets are not considered generators of high levels of agent in air.

Improve Equipment - Before performing reconnaissance in an area of unknown vapor concentration, ICs must consider the operational trade-off of time to suit up against the risk of further injury to potential casualties. This is especially critical if the number of potential casualties is high or if higher levels of protection, such as vapor-protective undergarments, are available.

WARNING

Minimizing rescuer exposure duration will minimize their potential hazard. However, a rescuer in standard turnout gear with SCBA is protected adequately for 30 minutes, even without taking time to apply quick fixes, such as duct tape. Time delays before rescuing known live victims may increase the cumulative dosage a victim receives. Quick entry, quick rescue, and quick exit, while diligently avoiding any contact with residual liquid contamination, will minimize the hazards to victims and rescuers.

Future improvements of FFPE may increase firefighter protection. As demonstrated by the quick fixes used during the MIST trials, the most important near-term improvement are closures around the neck, waist, and head, and seams in the groin area.

CB Helpline

CB Helpline is staffed weekdays from 9:00AM to 6:00PM Eastern Time, Monday through Friday. On weekends, holidays, and after normal business hours, callers can leave a voice mail message. Emergency responders can obtain information from the following sources:

CB Helpline:
(800) 368-6498
Facsimile:
(410) 436-0715
Electronic Mail Address:
Cbhelp@sbccom.apgea.army.mil
Internet address:
<http://www.nbc-prepare.org>

ABBREVIATIONS AND ACRONYMS

ASHRAE -	American Society of Heating, Refrigerating, and Air Conditioning Engineers
BALTEX -	Baltimore Exercises
CB -	Chemical Biological
CT -	Dosage (concentration over time)
DoD -	Department of Defense
ECBC -	Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD
FBI -	Federal Bureau of Investigation
FFPE -	Firefighter Protective Ensemble
GB -	Sarin (nerve agent)
GD -	Soman (nerve agent)
HAZMAT -	Hazardous Materials
HD -	Mustard (blister agent)
HVAC -	Heating, Ventilation, Air Conditioning
L -	Lewisite (blister agent)
IRP -	Improved Response Program
IC -	Incident Commander
MIST -	Man in Simulant Test
mg -	milligram
PBI -	Polybenzimidazole
PPDF -	Physiological Protective Dosage Factor
PPV -	Positive Pressure Ventilation
SCBA -	Self-Contained Breathing Apparatus
SBCCOM -	U.S. Army Soldier and Biological Chemical Command

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APPENDIX A

MANAGING THE CONSEQUENCES OF A CHEMICAL ATTACK: A SYSTEMATIC APPROACH TO RESCUE OPERATIONS

Managing the Consequences of a Chemical Attack **A Systematic Approach to Rescue Operations**

Modified with Permission from a Document of the Same Title¹

The guidelines below are intended to help first responders to a chemical agent attack develop an action plan to safely and effectively rescue live victims.

The Level A suit represents the highest level of protection to emergency responders against both respiratory and skin hazards of exposure to chemical (and biological) warfare agents. However, if the number of live victims exposed to and impaired by chemical agent(s) exceeds the availability of personnel in Level A suits to rescue in a timely manner, the Incident Commander must consider the use of other acceptable personal protective ensembles.

Turnout gear with Self-Contained Breathing Apparatus (SCBA) provides less protection than Level A suits, but will allow short exposures. Configurations of turnout gear with SCBA, listed in order of increased protection, include:

- Standard (no use of duct tape)
- Self-Taped
- Buddy-Taped
- Turnout gear over Tyvek undergarment

Saving **live victims** is the rescue mission, while minimizing risk of harm to the rescuers.

Note: First responders must gather information about the incident based on:

- signs and symptoms of casualties
- comments from casualties and onlookers
- previous responder reconnaissance or detector readings
- information available through intelligence provided by law enforcement officers
- site specific information
- current and forecast weather conditions

Note: First responders should not assume an incident involves a highly toxic chemical agent. The released material could be a less toxic industrial chemical or a riot control agent such as pepper spray.

¹ Montgomery County Fire and Rescue Service (MCFRS), Montgomery County, Maryland, December 1998 © MCFRS, Prepared by Deputy Chief Ted Jarboe, District Chief Robert Stephan, and Captain Jack Crowley with technical review by Roger McIntosh, M.D.

Key Factors and Steps to Help Decide Whether Rescue is a “Go” or a “No Go” Situation:

Weather Conditions: Consider the impact of wind direction and speed, temperature and humidity, and precipitation on the behavior and spread of the chemical agent(s) and on emergency operations. Use on-scene weather monitoring equipment if available.

Scene Hazard Assessment: Avoid “tunnel vision.” Don’t just assume chemical-related hazards. Also consider the possible presence of biological agents, radiological materials, and/or explosive devices.

Reconnaissance (Recon): Conduct Recon using the following steps to determine if live victims are still in the area of the chemical agent release.

1) Preliminary Assessment – If available, view the contaminated area through a closed window or an entrance doorway (or other upwind location) to gather victim information. Before entering the building, the Recon team must don at least turnout gear with SCBA. If:

- you observe living victims with nerve agent exposure symptoms
- victims have been exposed for 15 minutes or more
- mustard (HD) is not suspected, and
- the room the victims occupy is directly accessible without having to transit antechambers, stairwells, or other adjacent rooms

then the Recon mission is over and the Incident Commander can consider immediately starting the rescue mission (no longer than 30 minutes exposure for each responder) for live victims.

Note: If mustard is suspected, rescue can continue at increased risk to rescuers. Testing shows that 50% of rescuers exposed for 2 minutes would experience latent skin reddening in more susceptible areas, such as the groin. Rescuers staying in HD environments of unknown concentration for 30 minutes would not receive the 5% lethal dosage.

2) Search - If no living victims are visible from outside the building, the Incident Commander should assume a high concentration of chemical agent likely is present. However, the Incident Commander may consider a rapid reconnaissance by entering the building for no more than 3 minutes only to look for living victims.

Note: Before entry, the Recon team must increase their level of protection by at least self-duct taping protective clothing openings and closures and continuing SCBA use. Duct tape the following closures and openings as a minimum: the neck, around the face piece, the fly, wrists, ankles, waist, and the closure down the front of the jacket.

3) Rescue in Conjunction with Recon - During a quick reconnaissance inside the contaminated building, if:

- you observe living victims with nerve agent exposure symptoms
- victims have been exposed for 15 minutes or more, and
- mustard (HD) is not suspected

then the Incident Commander can assume nerve agent concentration is low and perform rescue for up to 30 minutes (see Rescue Team Exposure Time below).

Warning: Avoid transit of antechambers, stairwells, or adjacent rooms when evacuating victims discovered during Recon. These areas may have vapor, aerosol, or liquid chemical agent contamination that could further injure the victim or contribute to the rescuer's dosage.

Warning: Take special care to avoid contaminating footwear and clothing with liquid chemical agent. Skin contact with liquid chemical agent dosage may be lethal. Liquid contamination is very easy to spread. Spread liquid contamination will "offgas" highly toxic vapors and continues as a skin contact hazard.

4) Without Rescue in Conjunction with Recon - If no living victims are seen, then leave the building immediately, seal and secure the building, and wait for the HAZMAT team in Level A suits to arrive at the scene.

Victim Information:

Location: Are casualties visible near an entrance? Are they in the line-of-sight? Can they be heard? Estimate how long it would take to reach and remove them.

Number: If there are enough HAZMAT team personnel in Level A suits available to rescue live victims in a timely manner, use them. Otherwise, consider using personnel who are wearing an acceptable protective clothing alternative (i.e. taped or untaped turnout gear with SCBA), as approved by the Incident Commander.

Condition: Are casualties ambulatory or non-ambulatory? Signs and symptoms? Traumatic injuries? Entanglement? Mental state?

Rescue and Standby Teams: Select at least two personnel per team with appropriate personal protection. Ensure they are hydrated.

Chemical Agent Hazard Reduction: Consider use of positive pressure ventilation (PPV) fans or other fans to reduce or redirect vapor or aerosol concentration. Be sure that use of these fans will not spread chemical agent to endanger other people. If fans are acceptable, they should be placed in service while rescuers are donning their protective ensemble.

Review Information about Chemical Warfare Agents (CWA): The higher the vapor pressure of a CWA, the higher its rate of evaporation (volatility). Temperature and humidity can affect CWA properties and exposure risk.

SCBA (positive pressure): SCBA must be used for all rescue missions. Positive pressure or pressure demand SCBA provide an inhalation Protection Factor (PF) of at least 10,000.

Personal Protective Ensemble (PPE): Rescue personnel must wear standard turnout gear with SCBA. If the situation permits, PPE closures and openings should be taped with duct tape either by the responder or a buddy.

Rescue Team Exposure Time: Limit the initial exposure time to 30 minutes. No entry team will re-enter the contaminated area unless authorized and extreme circumstances clearly warrant doing so. Based on chemical warfare agent(s) released, the quantity, its properties, the circumstances surrounding its release, vapor suppression measures used, and any symptoms displayed by rescuers, the Incident Commander may allow rescue personnel to operate in the contaminated area for a longer period.

Warning: Because concentrations of the chemical agent released in a building could result in different concentrations in the rooms and corridors, victims should be removed through doors or windows that lead directly to the outside. If this is not possible, the rescuers should consider the use of escape masks or chemical masks by victims who must leave through other rooms and corridors to reach the outside.

Warning: Face Piece Removal. After exiting the rescue area, rescuers must continue using their SCBA until their decontamination is complete to prevent respiratory harm from "off-gassing" of chemical agent from the protective clothing. If possible, remove the regulator and face piece last (after protective clothing).

Emergency Decontamination: Unless delay would compromise rescue, set up the decontamination area before entry is made, locate setup upwind and as close as practicable, and monitor operations. Rescuers must be decontaminated immediately and before they remove their regulator and face piece (to avoid breathing any vapors possibly trapped in their clothing protective clothing) or any of their protective clothing. If possible, remove regulator and face piece last. Use chemical agent monitors.

Medical Monitoring: Check vital signs and ECG. Check again for chemical agent signs and symptoms.

Rehabilitation (REHAB): Provide rest and re-hydration. Re-check vital signs as necessary.

Remember this document is a guide. Existing conditions, knowledge of the chemical agents, good judgment, combined with available personnel and personal protective equipment, will greatly influence what level of protection is used by rescuers. The safety of both the rescuers and victims is of paramount concern. When Level A suits are not available, the mission of protected rescuers is to rescue live victims, nothing more.

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APPENDIX B

**LEVEL 2 REPRESENTATIVE SCENARIOS &
LEVEL 3 TABLES AND GRAPHS (PLATS)**

LEVEL 2 - REPRESENTATIVE EXPOSURE SCENARIOS FOR FIRST RESPONDERS

Level 2 provides realistic illustrations of potential real-world situations as examples of how to apply and interpret Level 3 results. Level 2 scenarios also are the basis for the modeling used to establish the Level 1 General Guidelines.

An indoor incident may be more likely to have higher vapor exposure than an outdoor event due to lower potential for air transport. Therefore, the three indoor exposure scenarios discussed below were selected to establish a credible range of potential event locations:

1. Large auditorium
2. Restaurant or eatery
3. Individual office or mailroom

For these three scenarios, the vapor hazard concentrations are assumed for each room type based on modeling. The predicted vapor hazard then was further modeled to account for the mitigating effects of air turnover due to natural and forced ventilation. Modeled results were based on the specific assumptions shown in Table A-1 below.

Table B-1. Assumptions for Room Ventilation and Agent Hazard Modeling*

Modeling Parameter		Modeled Room		
Factor	Units	Auditorium	Restaurant	Office
Floor Plan	Square Feet (Square Meters)	10,000 (930)	5,000 (465)	1,000 (93)
Ceiling Height	Feet (Meters)	25 (7.6)	10 (3)	8 (2.4)
Air Conditioning Rate	Cubic Feet per Minute (Liters Per Minute)	3,750 (107,000)	700 (20,000)	70 (2,000)
Ventilation Rate	Air Changes per Hour	0.54	0.84	0.105
Number of Persons	People	150	70	7
Agent Release Quantity	Quarts (Liters)	4 (3.6)	1.8 (2)	0.9 (1)

* Hazard estimates assume these conditions; different conditions will alter hazard estimates.

LEVEL 3 - TABLES AND GRAPHS

Level 3 results are intended to compliment, amplify, and provide insight into the operational recommendations provided by the General Guidelines and Table 2 in this report. These results may be used during planning and training to provide potential ICs with a better understanding of how maximum exposure time can vary as some of the REACT parameters, controllable and uncontrollable, are changed or vary.

To provide potential ICs with estimates of the credible range of potential terrorist events, the three different room types (office, restaurant, auditorium) described in Level 2 were modeled with three different chemical agent dissemination techniques (explosion, aerosol spray, spill).

Level 3 data are presented only for the chemical agents GB, HD, and VX. Even though terrorists could use other G-agents (GA, GD, and GF), these other agents all have an equal or lower toxicity to volatility ratio than GB. For this reason, GB is the limiting case.

Below is a summary of how these various results, both in the report and here in Appendix B, fit together:

- **Known Living Victims (Assumed Low Vapor Hazard)** – For all agents modeled in this report, fire fighters in turnout gear and SCBA will be protected from moderate chemical agent exposure effects if they remain in the hot zone not more than 30 minutes. This is emphasized in the report as part of the Level 1 General Guidelines.
- **Unknown Environment (Assumed High Vapor Hazard)** – Worst-case vapor exposure time recommendations are presented in the report in the rescue portion of the Level 1 General Guidelines, and in Table 2 for additional “quick fix” turnout gear configurations. These same results would be obtained in the Level 3 data for saturated vapor, the worst-case condition.
- **Representative Scenarios (Range of Vapor Hazards)** – Level 3 data provide a range of information for an assumed set of three potentially typical situations. Different types and sizes of dissemination devices and air handling parameters were assumed for each of these typical rooms.

Representative Scenarios

Level 3 is presented in a series of plats that give specific maximum exposure times in several credible scenarios for the Level 2 range of three representative indoor environments (office, restaurant, auditorium).

A "plat" is a set of graphs and tables that use known (or assumed) knowledge of the incident and the response to provide a refined estimate of maximum exposure time. The graphs and/or tables are used in sequence; the output from the first graph becomes the input to the next graph/table.

The curves in these plats show graphically how chemical agent vapor concentrations might be expected to change over time. For example, indoor air exchange (due to natural ventilation and air conditioning) will decrease the chemical agent concentration in a vapor-contaminated room over time. Conversely, as these plats illustrate, although spill concentrations are very much lower than concentrations from aerosol or explosive dissemination, spill concentrations may increase over time, even with air exchange, due to vapor offgassing from a spill.

For each of the three room configurations, four chemical agent dissemination techniques or conditions were modeled: aerosol device, explosion, spill, and saturated (see summary below). As listed in Table B-1, a different agent release quantity was assumed for each room type. This chemical agent quantity was modeled for each dissemination technique as follows:

- Aerosol Device - Continuous vapor for 10 minutes from a 200-ml "Preval" commercially available spray gun
- Explosion – Instantaneous vaporization of some or all liquid content of the concept munition used during Exercise Terminal Breeze '96
- Spill – Based on a simple model for spills on a flat surface; spill size based on surface tension
- Saturation – Assumes chemical agent maintains full, steady-state volatility (worst-case)

Eleven (11) plats are published at the end of this appendix to assist each jurisdiction and/or individual IC in understanding how maximum exposure times vary based on responder actions and the specific circumstances involved. They are intended primarily for planning and training purposes to give the IC ideas on a range of credible conditions.

How to Use Representative Scenario Plats

The potential IC must have the following information to use the graphs and table in the plats:

- Chemical Agent Type (Use GB for unknown nerve agent)
- Dissemination Technique Used (Explosive, Aerosol Spray Device, Spill)
- Time Since the Incident
- Type of Room (office, restaurant, auditorium)
- Responder FFPE
- First Responder Physiological Effect Dosage of Concern after Exposure

Most plats contain Graphs A, B, and C, and Table D (bottom left corner) which are used in sequence. Table D is identical for all plats of each given chemical agent. Follow these steps:

When to Use Representative Scenario Plats - Unlike the table for estimating entry into unknown environments or the General Guidelines, the plats allow the potential IC more insight into the effects of controllable decision parameters. For example, deciding to delay entry while first responders improve their degree of protection by self-taping or buddy-taping has two measurable effects. First, it improves each individual's suit physiological protective dosage factor, and it may allow additional ventilation of the hazard. However, living victims continue to be exposed and/or suffer trauma, and their decontamination and medical treatment is delayed.

For planning and training, potential ICs can compare effects of various decisions. In a specific illustration, we can compare two choices on how to respond to given conditions:

Situation: An explosion occurred in the mailroom of an FBI office. Several employees escaped the scene, but exhibit symptoms of nerve agent exposure. You do not know if there are rescuable victims still inside the mailroom.

Response 1: Responders enter 30 minutes after the event in standard turnout gear and SCBA. You use the default nerve agent vapor environment (GB) to estimate the maximum exposure time.

Response 2: You direct your responders to self-tape. Assume entry at 40 minutes after the event. Again, use the default nerve agent vapor environment (GB).

Response Comparison: If you plan for responders to operate until they might experience threshold symptoms, you gained 8.5 minutes operating time (from 11 minutes to 19.5 minutes) by deciding to self-tape, but at the cost of a 10-minute entry time delay.

If you use a reliable method to identify the chemical agent class or type and to quantify the residual agent vapor concentration, you can enter the plats directly.

Situation: A spray device was observed spewing a fruity smelling aerosol from the balcony of an old downtown movie theater. Victims exhibit nausea, vomiting, and convulsions; paramedics observe miosis (pinpoint pupils). In the course of helping to rescue non-ambulatory victims, a HAZMAT officer took a Dräger tube reading approximately 30 minutes after the incident began. The reading was 140 milligrams per cubic meter of the chemical agent GB. It now is 45 minutes after the event began, and an additional unit is ready to enter in turnout gear to relieve the first responders.

Response 1: You enter the GB Aerosol Spray plat for an auditorium beginning with the time since the event began (Graph A), 45 minutes.

Response 2: You enter the GB Aerosol Spray plat for an auditorium, not beginning with time since the event began (Graph A), but on the vertical (y-axis) of Graph B with 140 mg/m³.

Response Comparison: Using the predicted concentration at 45 minutes into the event (210 mg/m³) gives over a 55-minute maximum exposure time until onset of threshold symptoms. Using the actual concentration reading, which was lower than that predicted, indicates rescuers could operate in the hot zone more than 80 minutes before threshold symptoms may appear, even if you assume the GB vapor concentration has not decreased since it was measured. However, recall that exposures longer than 30 minutes must be performed with sensitivity to symptom onset because physiological protective dosage factors will fall off by an unknown amount after 30 minutes. Furthermore, most responders would exhaust their air supply and/or tire out before reaching these time thresholds.

Instructions for Use of Level 3 Plots

1. Choose the appropriate plat for the suspected (or known) chemical agent and suspected (or known) dissemination type. Use GB for unknown nerve agent. For reconnaissance, assume Saturated.
2. Enter Graph A with Entry Time (Minutes after Incident).
3. Draw a vertical line to cross the appropriate room curve.
4. From the intersection, draw a horizontal line onto Graph B to cross the appropriate FFPE configuration.
5. From the intersection, draw a vertical line onto Graph C to cross the appropriate dosage of concern.
6. From the intersection, draw a horizontal line left to the vertical axis.
7. Read the Expected Maximum Exposure Time (Minutes).
8. If this time is less than 30 minutes, enter the left column of Table D with this time and come across to the appropriate FFPE configuration. Interpolate (as required) to find the actual time a rescuer can be exposed.

Table D is a physiological protective dosage factor correction table because the protection offered during only short exposures can be much greater than the protection offered during a full 30-minute exposure. Using Table D is more critical with low expected maximum exposure times, or for higher levels of protection such as buddy-taping or Tyvek undergarment.

Note: Expected Maximum Exposure Times greater than 30 minutes must be used with caution. They assume the same physiological protective dosage factor as the average tested value over a 30-minute trial. The actual physiological protective dosage factor for exposure times over 30 minutes has not been determined by testing, but is expected to decrease from the 30-minute average used.

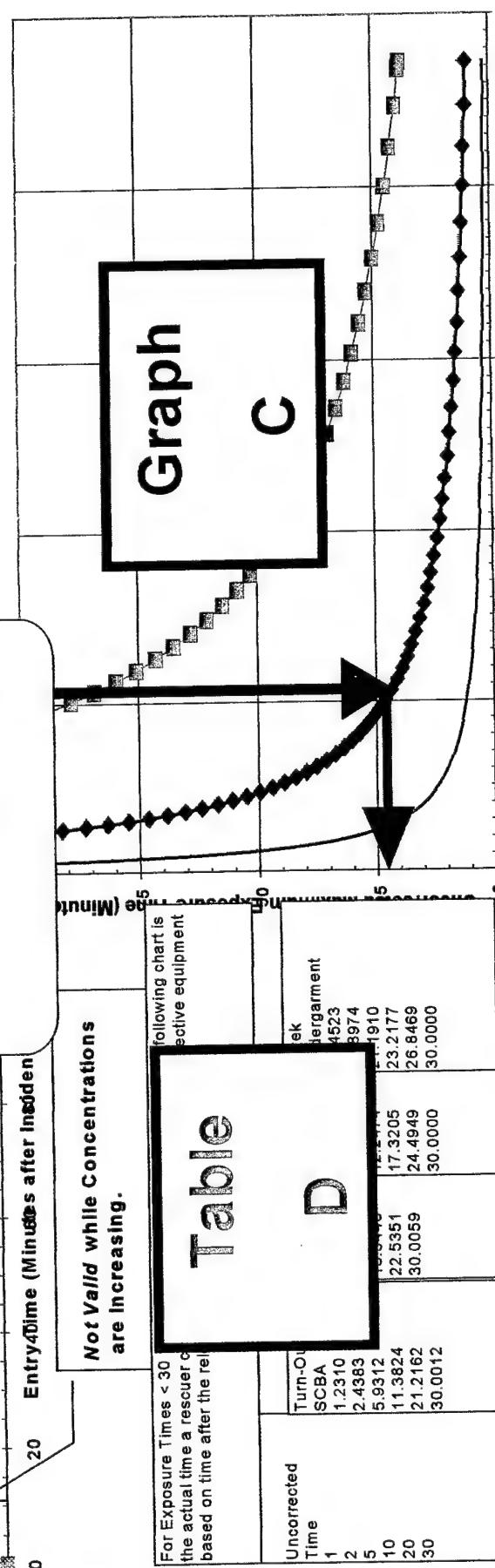
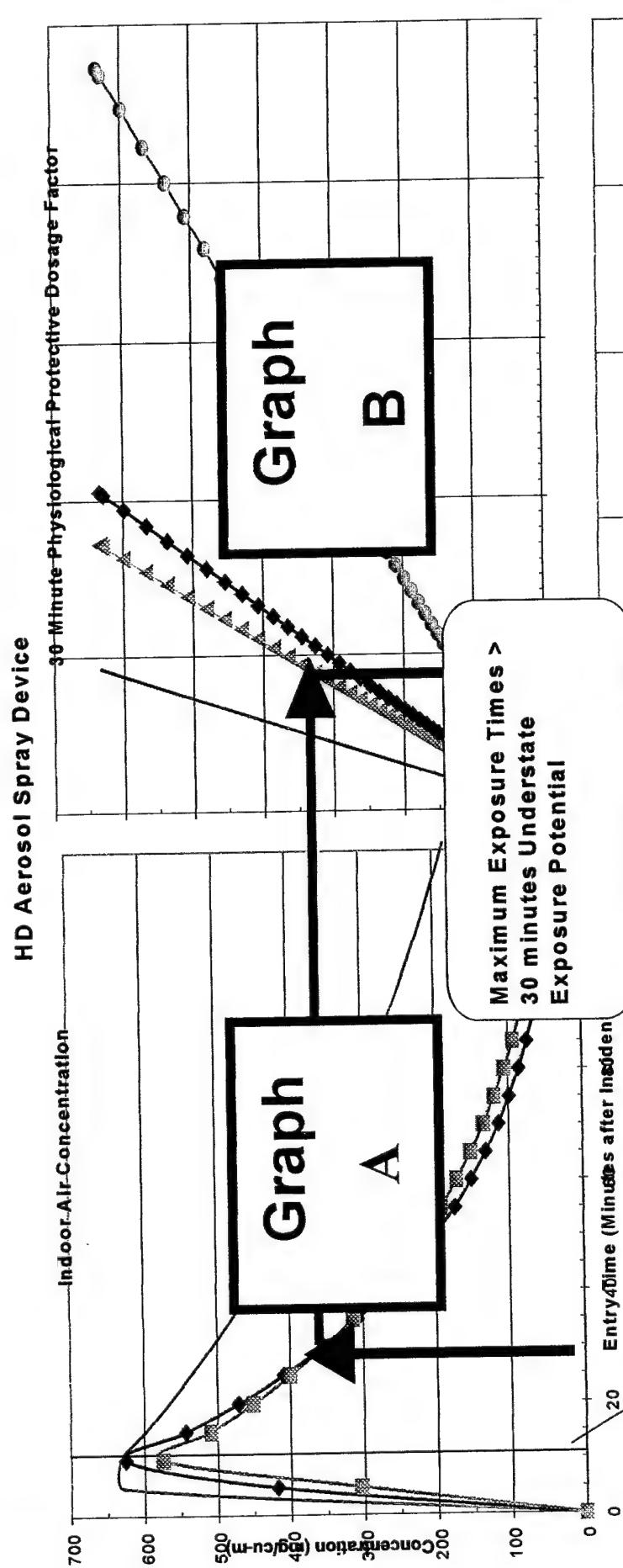
Alternative Procedure: Agent Concentration Known

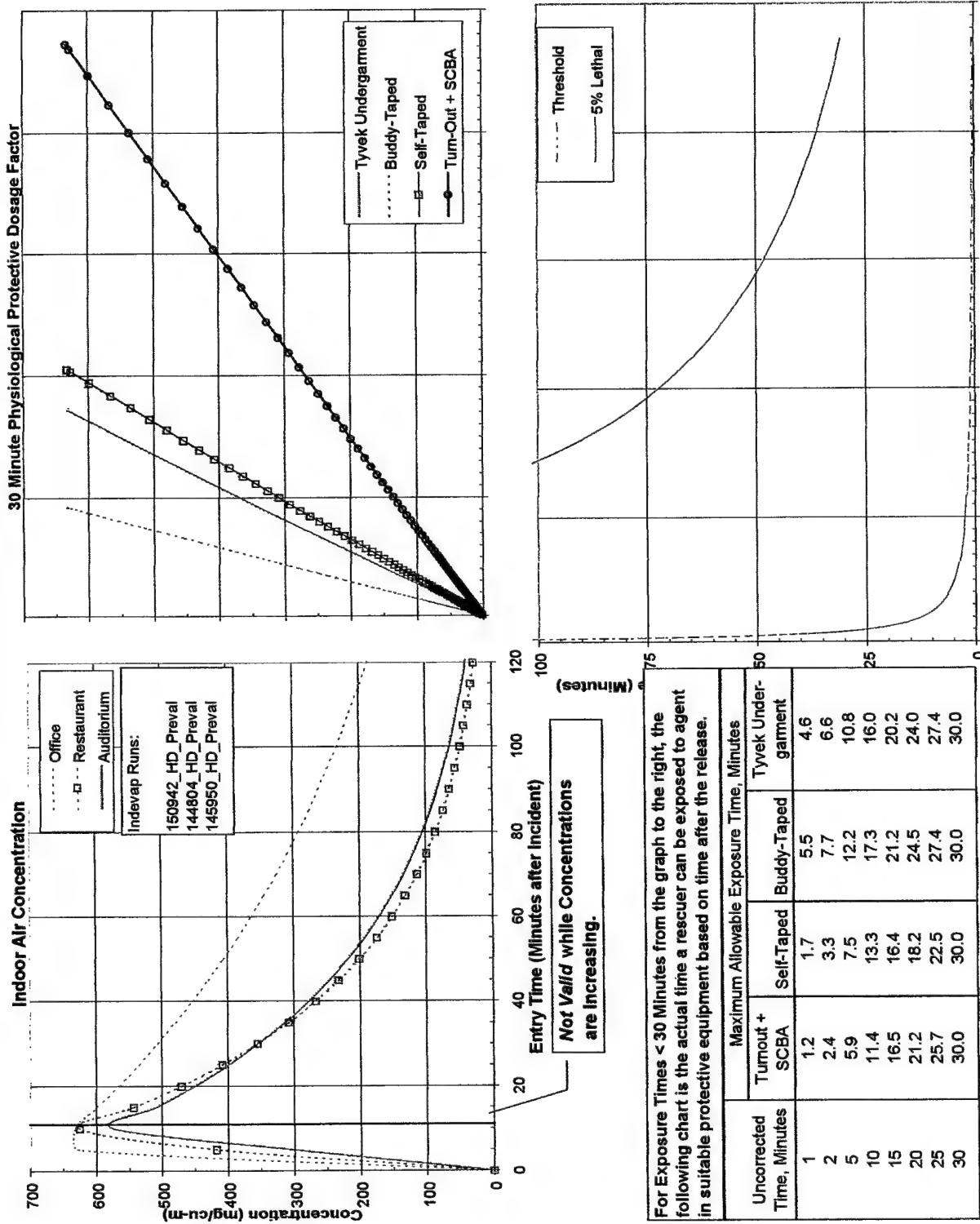
1. Bypass Graph A by entering Graph B directly with concentration in mg/m³.
2. Continue through remaining plat as above.

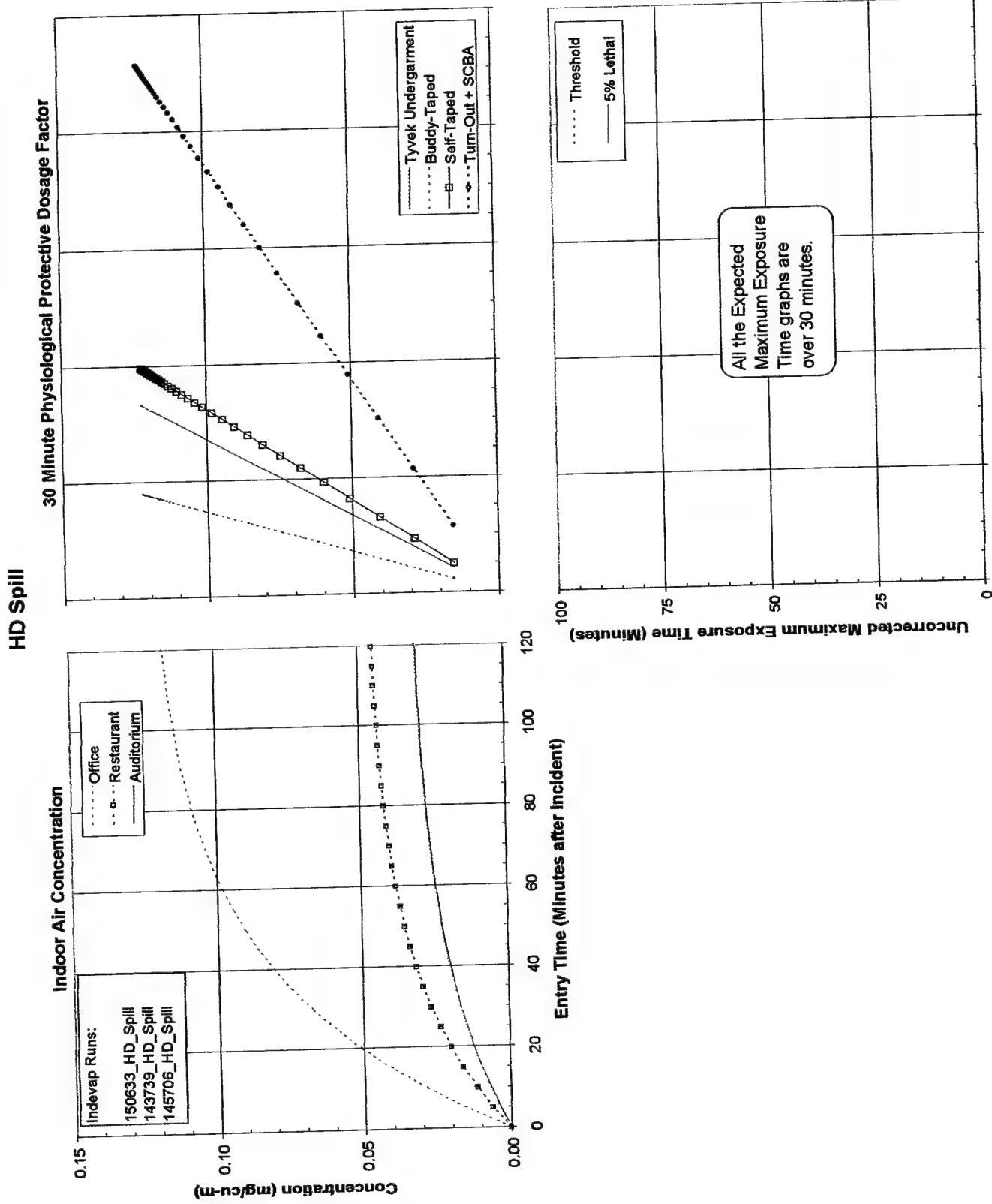
Index and Contents of Level 3 Plats

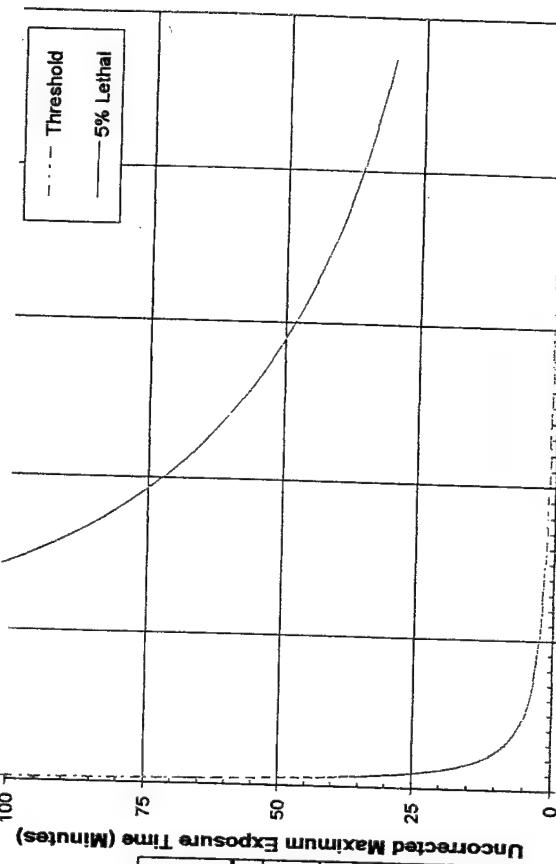
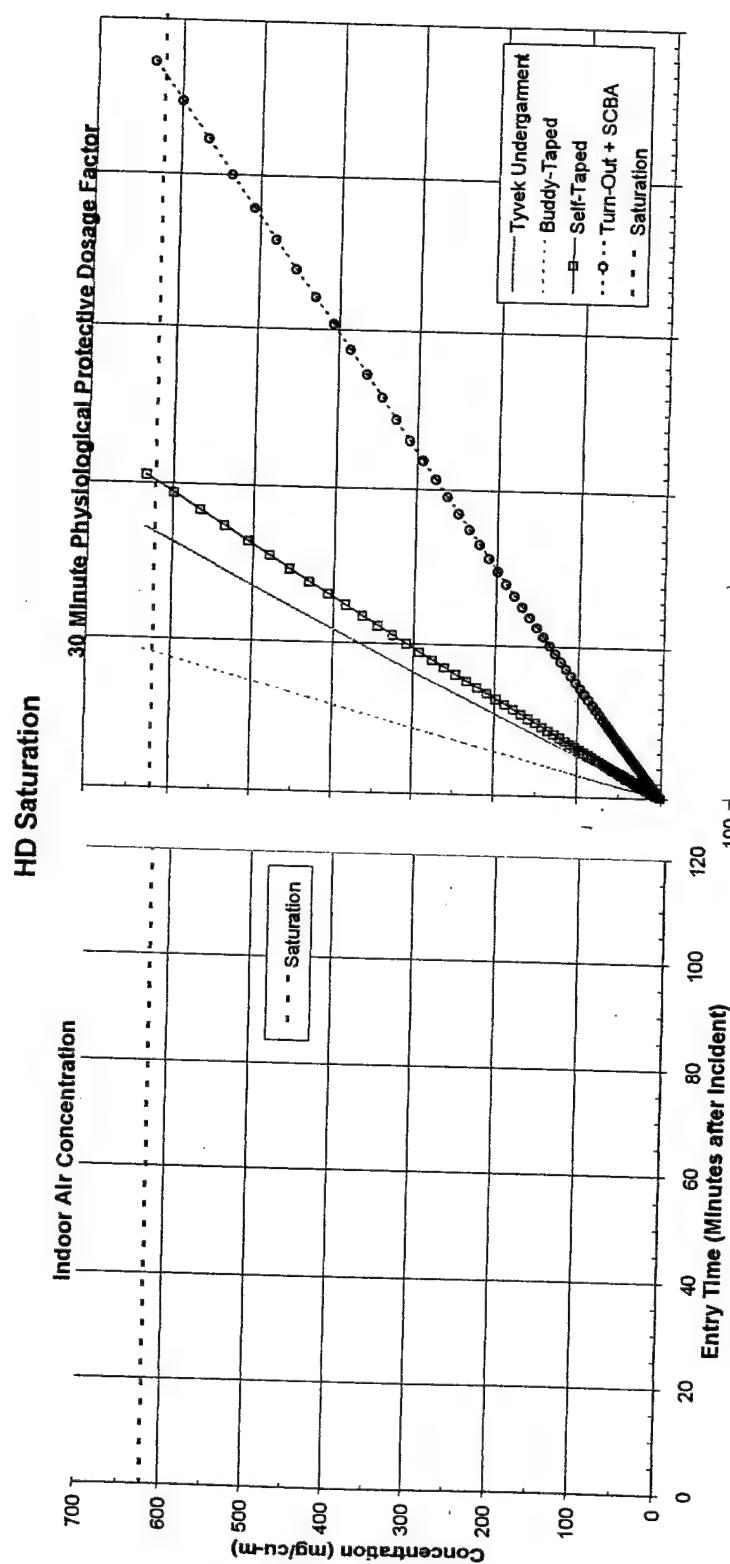
Agent	Dissemination Technique Or Concentration Level	Level 2 Scenario Listed			Physiological Dosages	
		Office	Restaurant	Auditorium	Threshold	5% Lethal
HD	Aerosol Device	●	●	●	●	●
	Explosion	●	●	●	●	●
	Spill	●	●	●	All Addressed ¹	
	Saturated	●	●	●	●	●
GB	Aerosol Device	●	●	●	●	●
	Explosion	●	●	●	●	●
	Spill	●	●	●	All Addressed ¹	
	Saturated	●	●	●	●	●
VX	Aerosol Device	●	●	●	●	●
	Spill	●	●	●	All Addressed ¹	
	Saturated	●	●	●	●	●

¹ Individual curves are not provided because the hazard is relatively low



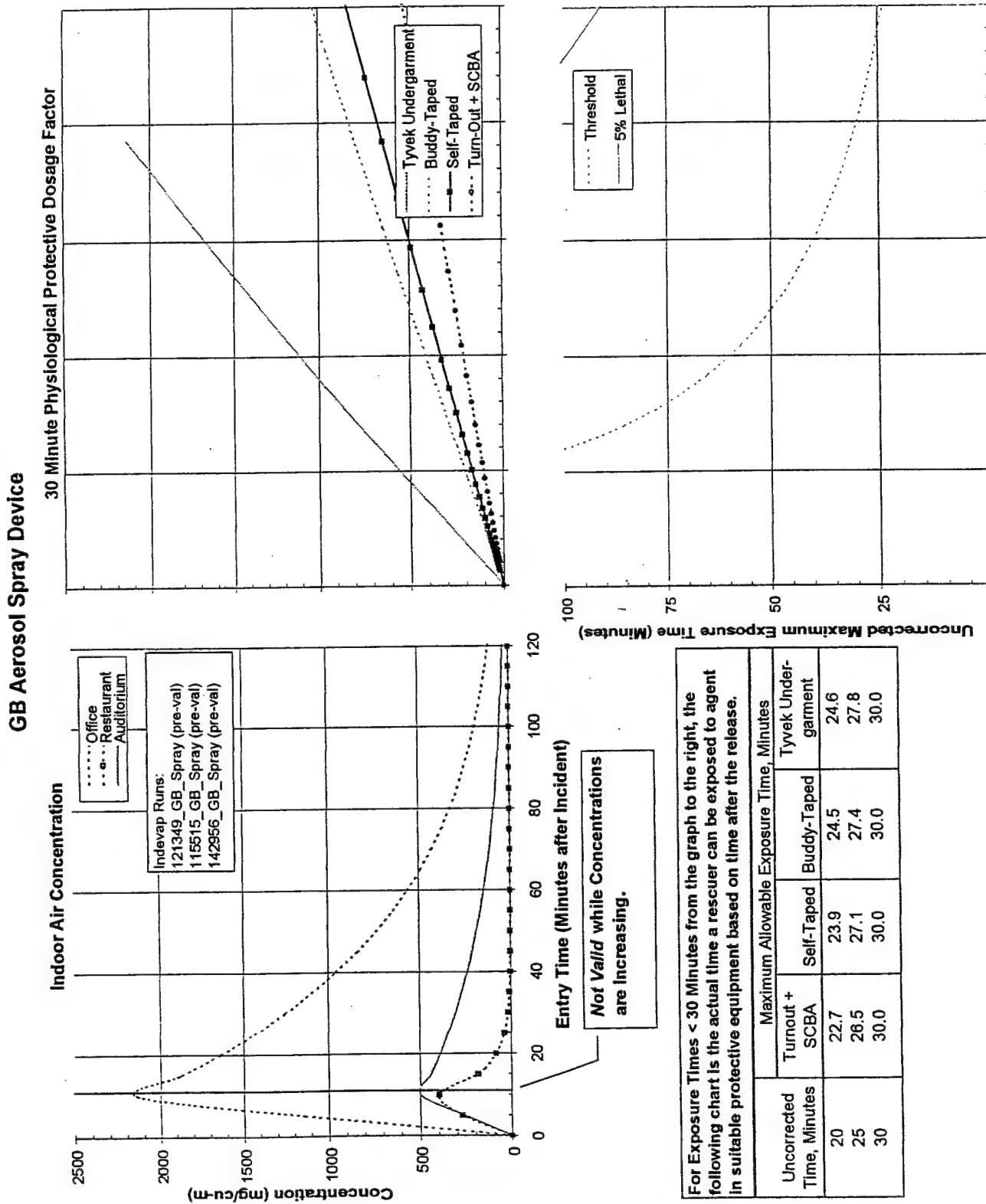
HD Aerosol Spray Device



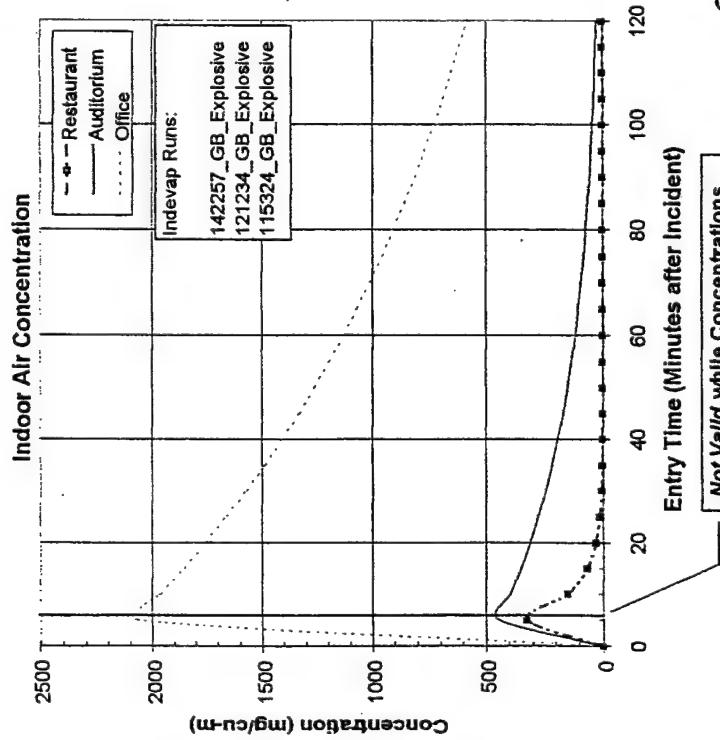


Uncorrected Time, Minutes	Maximum Allowable Exposure Time, Minutes			
	Turnout + SCBA	Self-Taped	Buddy-Taped	Tyvek Undergarment
1	1.2	1.7	5.5	4.6
2	2.4	3.3	7.7	6.6
5	5.9	7.5	12.2	10.8
10	11.4	13.3	17.3	16.0
15	16.5	16.4	21.2	20.2
20	21.2	18.2	24.5	24.0
25	25.7	22.5	27.4	27.4
30	30.0	30.0	30.0	30.0

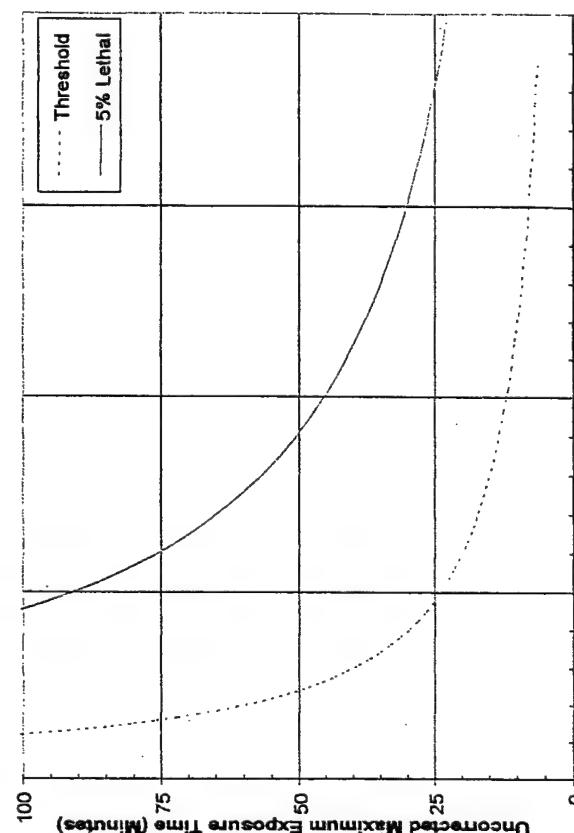
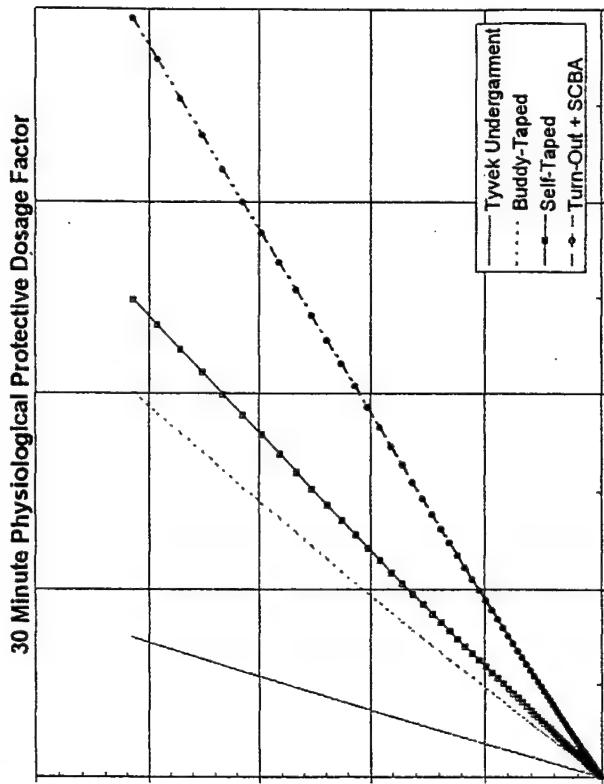
For Exposure Times < 30 Minutes from the graph to the right, the following chart is the actual time a rescuer can be exposed to agent in suitable protective equipment based on time after the release.



GB Explosive Device

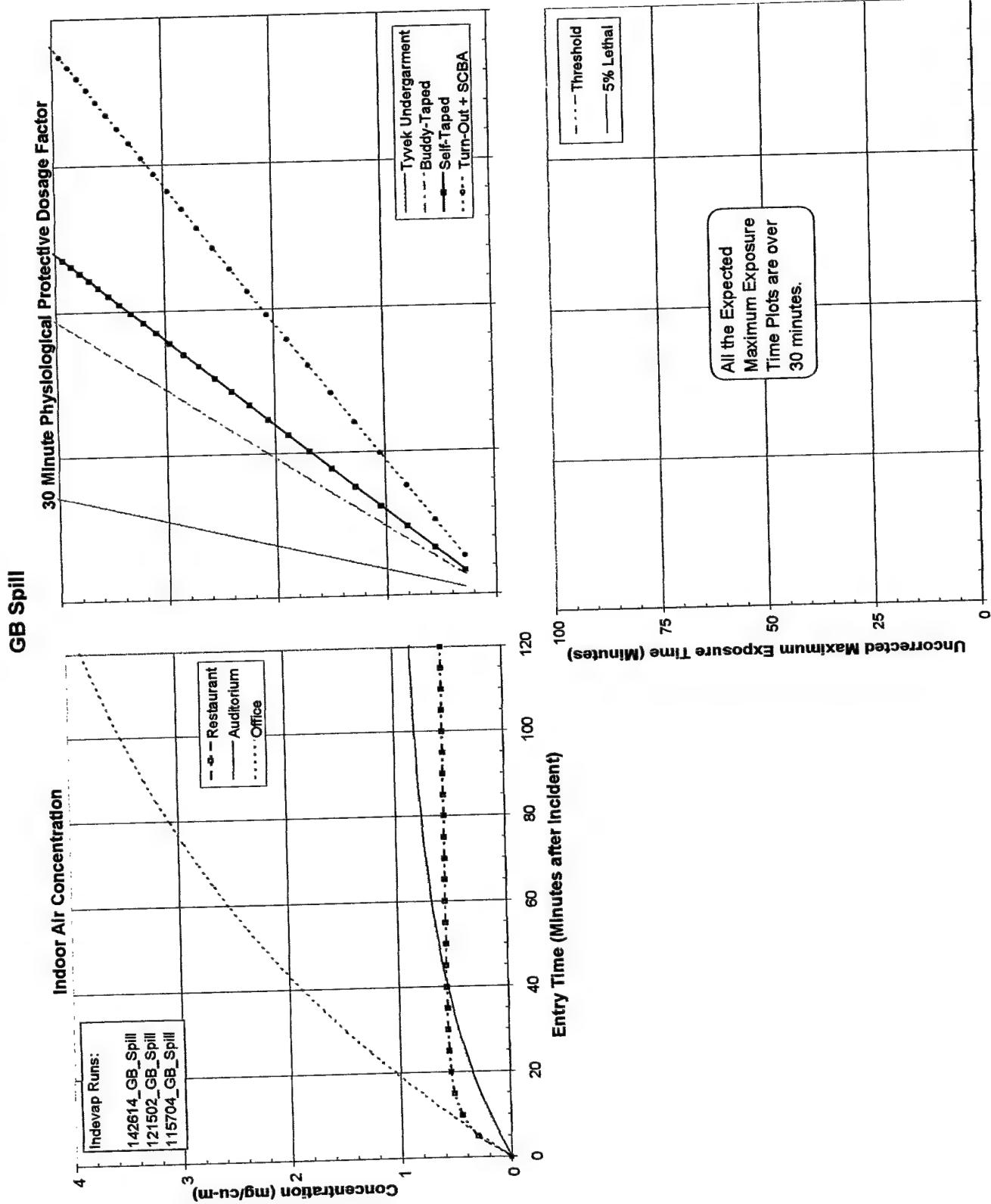


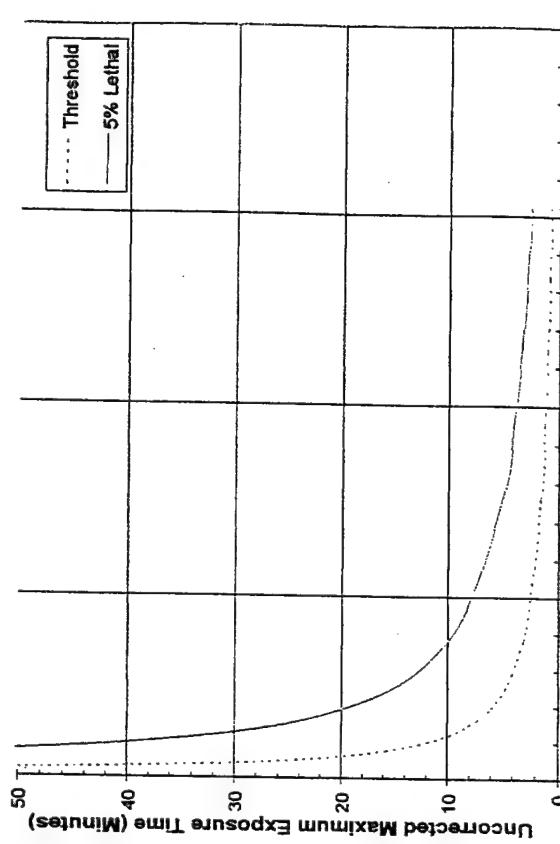
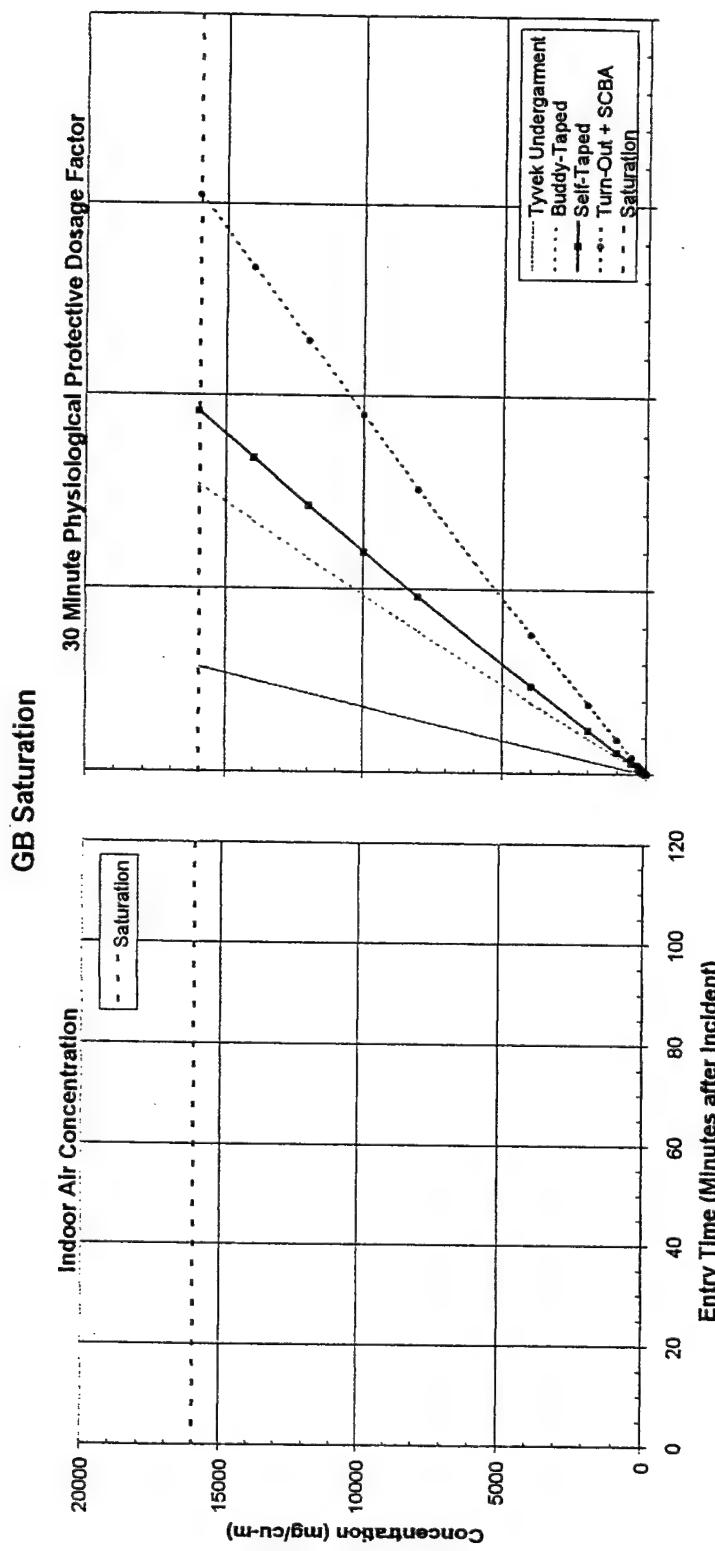
Not Valid while Concentrations
are Increasing.



For Exposure Times < 30 Minutes from the graph to the right, the following chart is the actual time a rescuer can be exposed to agent in suitable protective equipment based on time after the release.

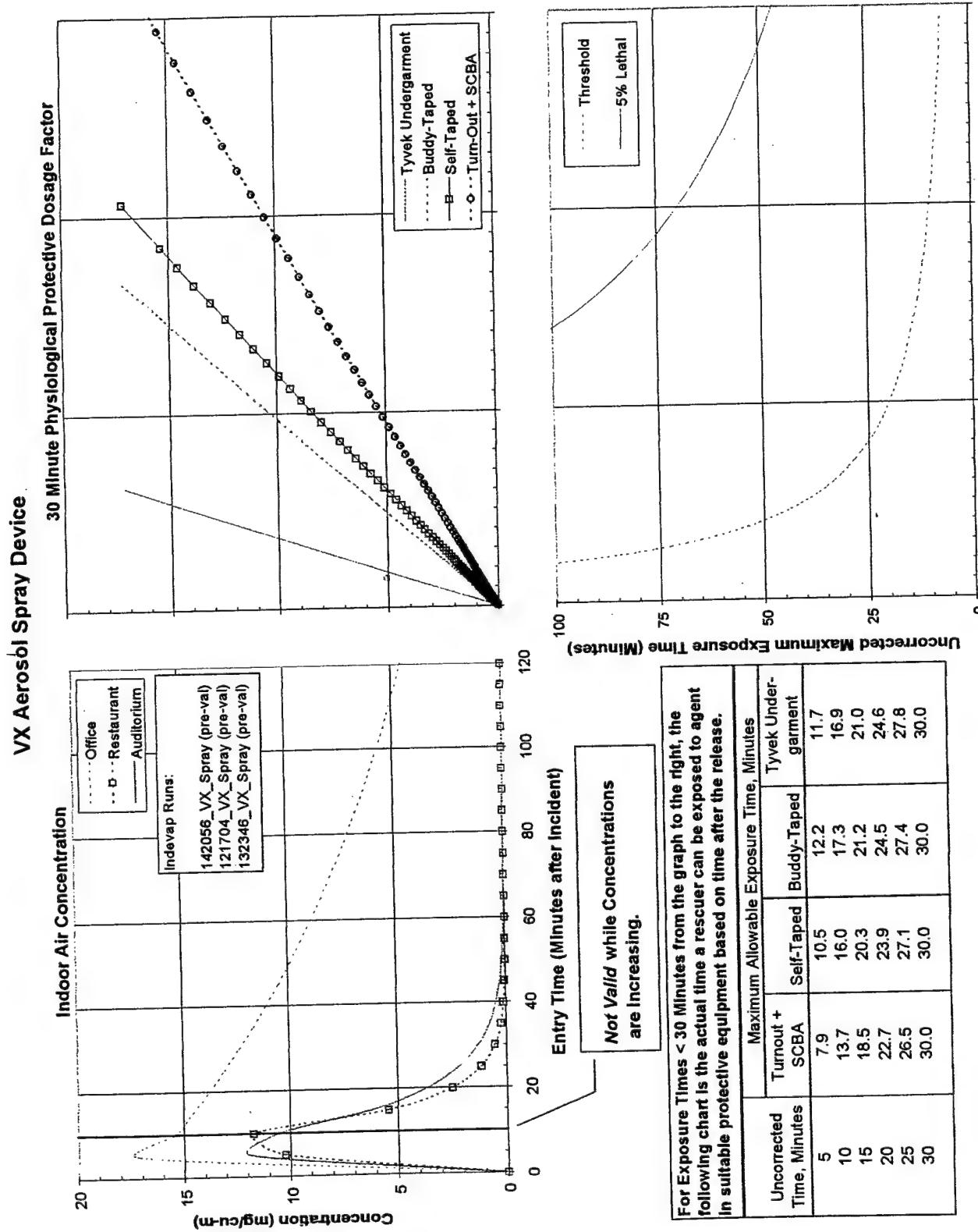
Uncorrected Time, Minutes	Maximum Allowable Exposure Time, Minutes		
	Turnout + SCBA	Self-Taped	Tyvek Undergarment
5	7.9	10.5	12.2
10	13.7	16.0	17.3
15	18.5	20.3	21.2
20	22.7	23.9	24.5
25	26.5	27.1	27.4
30	30.0	30.0	30.0

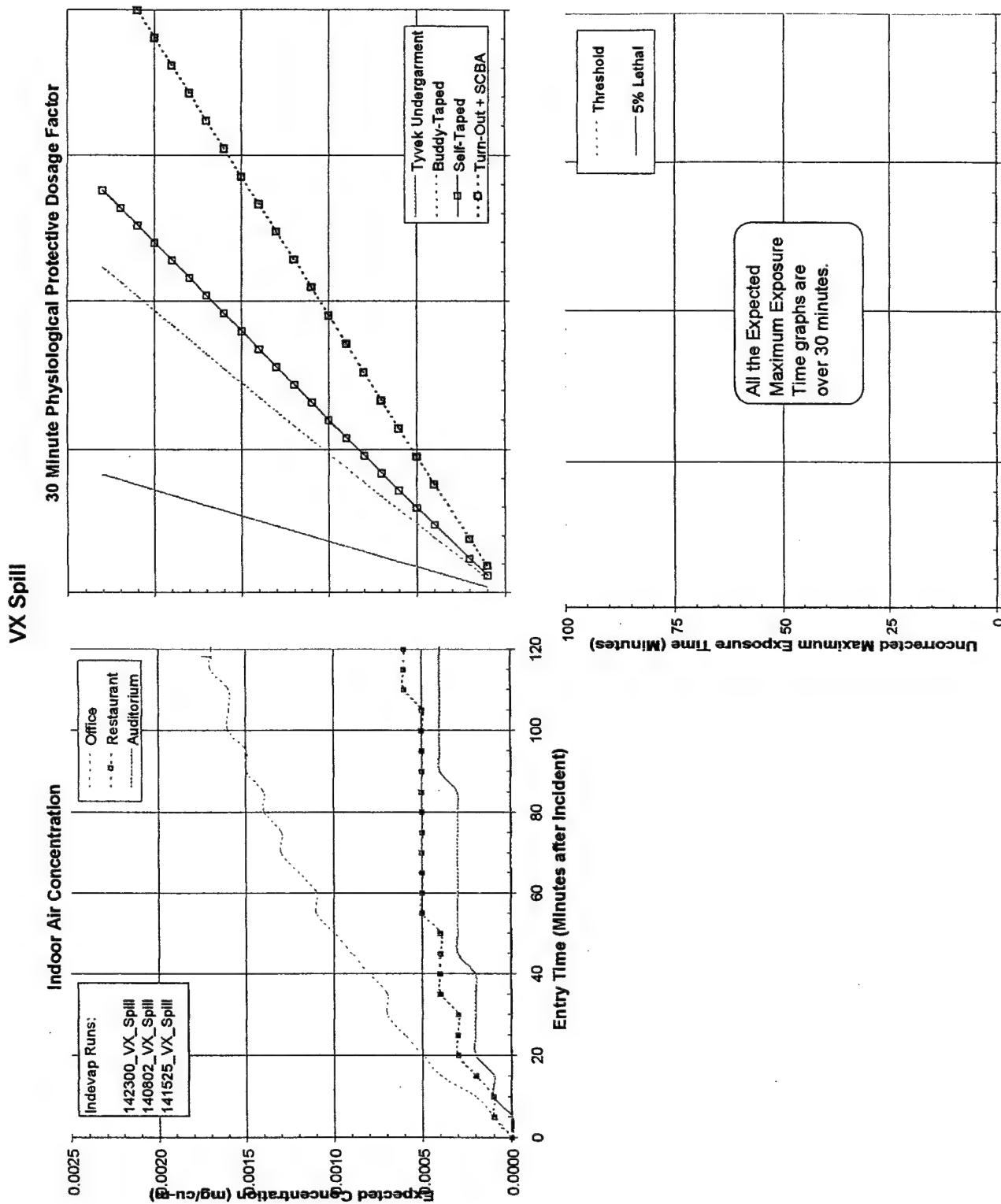


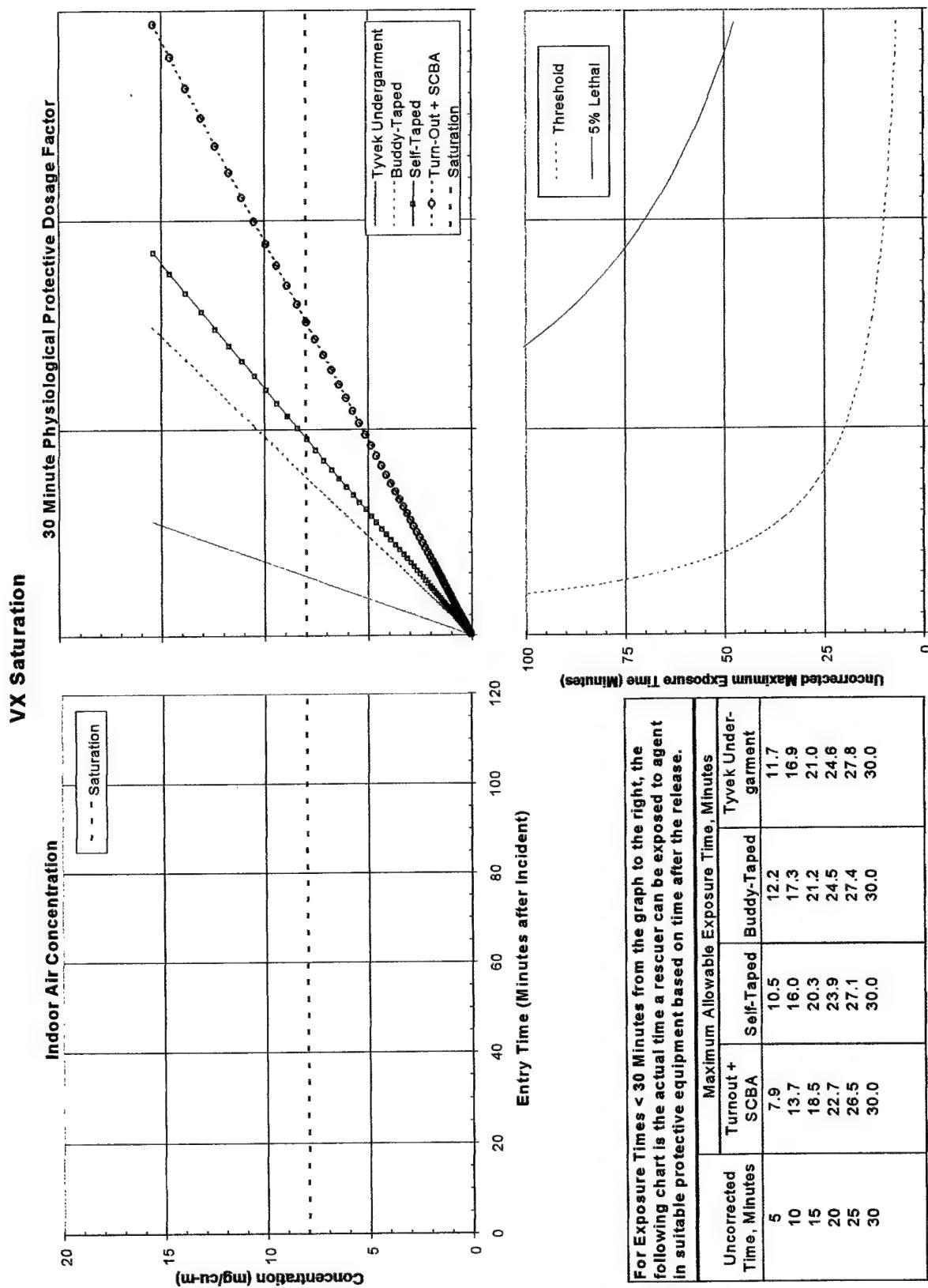


For Exposure Times < 30 Minutes from the graph to the right, the following chart is the actual time a rescuer can be exposed to agent in suitable protective equipment based on time after the release.

Uncorrected Time, Minutes	Maximum Allowable Exposure Time, Minutes		
	Turnout + SCBA	Self-Taped	Buddy-Taped
1	1.9	3.5	5.5
2	3.5	5.7	7.7
5	7.9	10.5	12.2
10	13.7	16.0	17.3
15	18.5	20.3	21.2
20	22.7	23.9	24.5
25	26.5	27.1	27.4
30	30.0	30.0	30.0







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APPENDIX C

INCIDENT COMMAND (IC) RESEARCH TEAM: CHARTER, MEMBERSHIP, AND PROCESS

Improved Response Program (IRP)

The U.S. Army Soldier and Biological Chemical Command (SBCCOM), Aberdeen Proving Ground, Maryland has the mission of developing an Improved Response Program (IRP) to identify problems and develop solutions to the tasks faced by first responders in responding to nuclear, biological, and chemical terrorism incidents. The SBCCOM formed both a chemical and a biological team.

The chemical team includes a broad cross-section of operations and technical experts from local, state, and federal agencies. Most experts in responder operations are volunteers from the Baltimore-Washington DC area, but other experts from across the nation also ensure that solutions are broad-based and adaptable by any jurisdiction. Team members generally are drawn from fire departments, emergency management offices, law enforcement agencies, and military test and evaluation agencies, but also include legal experts, medical doctors, computer modelers, operations researchers, and environmental scientists.

The chemical team formed specific "research teams" to address issues that evolved from a series of tabletop exercises called BALTEX (Baltimore Exercise).

Incident Command (IC) Research Team

Once results from FFPE vapor testing were available, a team was formed with representation from technical and operational perspectives. The IC research team charter was to apply and present the ECBC MIST test results to be most useful to first responders. The team completed a survey, conducted interviews, and met as a group to ensure the format and content of any modeled results can be used easily at all levels of operation when responding to a chemical incident.

During on-site interviews with groups of first responders, special emphasis was placed on getting feedback from fire fighters at all levels, not only those in leadership roles. The first responders polled were offered choices ranging from simple tables with many built-in assumptions to more complex graphs with a full range of entry parameters. With direct perspectives both on what senior and more junior potential incident

Incident Command Research Team Members

Area	Specialty	Organization
First Responder	Fire Department	Montgomery County (MD) FRS Baltimore County (MD) FD Washington (DC) FD Howard County (MD) FRS Columbus (OH) DFRS Baltimore City (MD) FD Baltimore County (MD)
	Emergency Management	
Technical Reporting	Operations Research	Battelle Memorial Institute U.S. Army SBCCOM
	Modeling & Analysis	Battelle Memorial Institute Optimetrics Incorporated
	Testing	U.S. Army SBCCOM
First Responder	Fire Department	Los Angeles (CA) FD Aberdeen Proving Ground (MD) FD

Summary Insert

commanders need to make the best decisions, the team was able to recommend data formats for all expected users. A full range of technical and operational reviewers offered comments and critiques that were addressed and incorporated into the final report.

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APPENDIX D

SIGNS AND SYMPTOMS OF CHEMICAL AGENT EXPOSURE

NOTE: Most of this appendix was extracted from WMD Domestic Preparedness Training Program materials.

After exposure to chemical agents, victims may present one or more of the symptoms described by the acronym "SLUDGE". The table on the following page associates specific signs and symptoms with specific chemical agents.

Determining from signs and symptoms alone that a victim has been exposed to a chemical agent can be difficult for a first responder. In general, at least two signs or symptoms should be present to limit the risk of mistaking exposure to less toxic substances with exposure to chemical agents.

SLUDGE				
S	-	Salivation	-	Drooling
L	-	Lacrimation	-	Tearing
U	-	Urination		
D	-	Defecation		
G	-	Gastrointestinal; pain and gas		
E	-	Emesis	-	Vomiting

DPT 7.0 

Protection from chemical agents requires full respiratory and skin protection. Your turnout gear, properly worn, will provide you with some protection.

Nerve agent antidotes are available and decontamination will work if you get the liquid chemical agent off your skin quickly. Flushing with water likely is the most expedient and widely available decontamination process.

Nerve agents are heavier than air. The G agents are fairly non-persistent, but VX is very persistent. There is a first aid antidote.

Clothing contaminated with nerve agents can "off gas", creating a problem for individuals around undecontaminated clothing who are unprotected.

Chemical Agents, Type, Symptoms and Hazard

Symbol/ Common Name	CAS Number	Possible Agent Type	Symptoms	Physical Characteristics	Hazard
GA (Tabun)	77-81-6	Nerve	Pinpointing of the pupils Dimness of vision Runny nose/salivation Tightness of chest Difficulty breathing Twisting or paralysis Tachycardia Vomiting Loss of consciousness Convulsions Incontinence Death	Colorless to lightly colored liquid at normal temperature. G agents slightly less volatile than water. V-agents about as volatile as motor oil	Respiratory effective within seconds to minutes.
GB (Sarin)	107-44-8				Skin dose effective in minutes to hours.
GD (Soman)	96-64-0				Extremely toxic/lethal agents.
VX	50782-69-9				
H	505-60-2	Vesicant (Blister Agent)	Reddening of skin Blisters Eye pain and redening Eye damage Coughing Airway irritation and damage	Oil light yellow to brown liquids with a strong odor of garlic. Fishy Odor H and HD freeze at 57 degrees F. All are volatile at room temperature.	
HD	505-60-2				
HN (all commonly called "mustard")	538-07-08				
L (Lewisite)	541-25-3	Vesicant	Immediate pain or irritation of skin Other symptoms similar to the i- agents	Oil collossal liquid with the odor of geraniums. More volatile than H.	Immediate pain. Other symptoms in about 12 hours. Can be lethal in large doses.
CX (phosgene oxime)	35274-08-9	Vesicant		A solid below 95 degrees F, but vapor can result.	Immediate pain. Other symptoms shortly thereafter. Can be lethal in large doses.
AC (hydrogen cyanide)	74-90-8	Blood	Cherry red skin or lips Rapid breathing Dizziness Nausea, vomiting Headache Convulsions Death	Rapid evaporating liquids.	Can cause death in 6-8 minutes.
CK (Cyanogen chloride)	506-77-44				
CG (Phosgene) Chlorine	75-44-5	Choking			In very high doses, can result in death after several days.

**Domestic
preparedness**